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PROCEEDINGS OF THE TWENTY-SEVENTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

UNIVERSITY OF NORTH CAROLINA, APRIL 27 AND 28, 1928

The twenty-seventh annual meeting of the North Carolina Academy of Science was held at the University of North Carolina, Chapel Hill, North Carolina, April 27 and 28, 1928. The meeting was called to order at 10:30 a.m. by the President. The reading of papers was begun and continued until 1:30 p.m., when the following committees were appointed:

Auditing—A. W. Hobbs, C. W. Edwards, J. B. Derieux.

Nominating—Bert Cunningham, Z. P. Metcalf, A. H. Patterson.

Resolutions—J. P. Givler, F. A. Wolf, Miss Lula G. Winston.

The Academy adjourned for luncheon as guests of the University.

The reading of papers was begun again at 3:00 p.m., and continued until 4:00 p.m., when the Academy went into business session.

The minutes of the previous meeting were approved as published in the *Journal of the Elisha Mitchell Scientific Society.*

Reports were called for from the various committees.

The Committee on High School Science, consisting of Bert Cunningham, chairman, R. N. Wilson, and C. M. Heck made the following report:

"The Committee on High School Science reports that members of the committee attended each of the section meetings of the N. C. Teacher's Association, and assisted in the programs.

This phase of the work of increasing interest in science will probably suffer as the Association has no available funds for its continuance.

The High School Science Prize has evidently stimulated much interest in the state. Some twenty-five essays were submitted. The committee consisting of R. N. Wilson, chairman, P. M. Ginnings and L. B. Rhodes unanimously selected Mr. H. E. Biggs, Jr., Greensboro High School, as the winner of the prize. Second honors were shared by Mr. J. D. McNairy, Greensboro High School, and Mr. F. M. James, Hanover High at Wilmington.

The committee recommends that the Secretary of the Academy notify the winners and arrange for the awarding of the prize."

The report was accepted.

The Executive Committee, consisting of J. M. Bell, President of the Academy; W. L. Porter, Vice-President; H. R. Totten, Secretary and Treasurer; H. B. Arbuckle, J. W. Nowell, and A. H. Patterson, reported as follows:

The Executive Committee met at Chapel Hill, April 26 and again on April 27, with all members present.

The Committee refused all requests for more than 15 minutes for the presentation of papers before the General Section; but left the matter of time for the other sections to the sections concerned.

The Committee also refused all requests for advancing papers from their positions as printed on the program. The Committee, however, decided to move back Mr. A. A. Dixon's paper on "The Brown Mountain Light" so as to place it as the first to be presented Friday afternoon.

The Committee makes the following recommendations to the Academy:

1. That all bills presented in the Treasurer's report be authorized and paid and that the report be printed when audited.

2. That H. B. Arbuckle be appointed a committee of one to select the cup to be given to the winner of the High School Science Essay Prize and that he be authorized to draw upon the Treasury for as much as $20.00 for the cup. And that the Academy send a representative to the high school commencement of the Greensboro High School to deliver this Academy prize to the winner. And that the Secretary be authorized to select the Academy representative and to pay from the Academy funds the expenses of this representative.

3. That the Executive Committee be authorized to schedule the presentation of papers for the next annual meeting on Thursday and Friday in order to leave Saturday open for field trips, exhibits, and visits to manufacturing plants if the local committee on arrangements can arrange suitable trips, exhibits, and visits.

4. That the Academy accept the invitation from the North Carolina College for Women to hold the twenty-eighth annual meeting of the Academy in Greensboro.

The Committee authorized the Editorial Board of the Academy to publish the Constitution and By-Laws of the Academy, revised to date, with a list of the past officers of the Academy and the present roll; and to prepare 750 reprints for distribution to prospective members.

The Committee reports as elected to membership since the last annual meeting the following:

Ader, Olin Blair, Graduate Student in Physics, Duke University.
Avery, George Sherman, Jr., Instructor in Botany, Duke University.
Bailey, J. L., Teaching Fellow in Zoology, University of North Carolina.
Beers, Charles Dale, Assistant Professor in Protozoology, University of North Carolina.
Bell, Francis M., Graduate Student in Civil Engineering, University of North Carolina.
Bomar, Miss Willie Melmoth, Teacher in Foods and Nutrition, East Carolina Teachers College.
Braudwell, Leslie Jarrett, Science Teacher, Salisbury High School.
Brooks, Grady Stoddard, Senior in Biology, Davidson College.
Brown, B. F., Physics Department, State College.
Bullock, R. C., Instructor in Mathematics, University of North Carolina.
Cameron, Frank K., Professor of Chemistry, University of North Carolina.
Chapin, Miss Ethel M., Professor of Chemistry, Asheville Normal.
Clifford, Alfred Turner, Assistant in Chemistry, University of North Carolina.
Eliason, Miss Mary Howell, Teacher of Biology, Mitchell College.
Fisher, Hilbert A., Assistant Professor of Mathematics, State College.
Goldston, Eugene F., Student in Geology, State College.
Graham, Miss Maria D., Teacher of Mathematics, East Carolina Teachers College.
Gray, Miss Cora E., Catawba College.
Hill, L. L., Graduate Student in Zoology, University of North Carolina.
Hirsch, Nathaniel D., Instructor in Psychology and Philosophy, Duke University.
Hopkins, Dwight Lucian, Instructor in Zoology, Duke University.
Ingraham, Miss Helen, Assistant Professor of Biology, North Carolina College for Women.
Jones, E. P., Duke University.
Kirkpatrick, D. E., Student in Physics, Duke University.
Klemm, Miss Ethel M., Instructor in Biology, Asheville Normal.
de Laubenfels, Max Walker, Zoologist, Carnegie Institution.
Lawson, Robert Baker, Physical Director, University of North Carolina.
Ledbetter, Miss Ida Bell, Professor of Biology, Appalachian State Normal.
Lee, Mrs. Selma M., Graduate Student in Zoology, University of North Carolina.

Lineberry, Miss Margaret, Graduate Student in Biology, Wake Forest.
Mangum, C. S., Professor of Anatomy, University of North Carolina.
Matthews, Andrew Clark, Assistant in Botany, University of North Carolina.
McCrea, Thomas Russell, Chemist-Bacteriologist, North Carolina Department of Fisheries and Assistant Sanitary Engineer of the State Board of Health, Morehead City, N. C.
McDougall, William, Professor of Psychology, Duke University.
McPhaul, Angus Hinton, Student in Biology, Davidson College.
Mills, Ralph Cordell, Engineer, Harris Granite Quarry Company, Salisbury, N. C.
Murray, Victor Feodor, Professor of Mathematics and Physics, Catawba College.
Perry, J. Whitney, Graduate Student in Physics, Duke University.
Pleasants, Miss Annie Lewis, Instructor in Biology, North Carolina College for Women.
Potter, Robert D., Graduate Student in Physics, Duke University.
Preston, Carleton Estey, Associate Professor of Science Teaching, University of North Carolina.
Purdom, Emil Garness, Professor of Physics, Guilford College.
Rankin, William Walter, Professor of Mathematics, Duke University.
Reinholt, Oscar R., Oil Specialist, Winston-Salem, N. C.
Rogers, J. S., Chemist, Morganton, N. C.
Roseberry, Horace Hewell, Instructor in Physics, Davidson College.
Sharpe, Miss Lucile, Senior in Biology, North Carolina College for Women.
Smiley, T. B., Instructor in Electrical Engineering, University of North Carolina.
Smith, Arlie R., Professor of Chemistry, Appalachian State Normal.
Snyder, Lawrence H., State College.
Stanfield, Wesley, Student in Zoology, Duke University.
Terrill, Miss Elizabeth Durant, Professor of Chemistry, St. Marys School.
Thomas, Charles LaMar, Assistant in Chemistry, University of North Carolina.
Traver, Jay R., Instructor in Biology, North Carolina College for Women.
Trawick, Martin Whitford, Instructor in Physics, University of North Carolina.
Wentz, Bruce Albion, Professor of Psychology and Philosophy, Catawba College.
Whitford, L. A., Instructor in Botany, State College.
Whiting, Mrs. P. W., Associate Professor of Biology, Catawba College.
Williams, Miss Maude, Instructor in Physiology, North Carolina College for Women.
Winsor, Arthur S., Associate Professor of Mathematics, University of North Carolina.

Reinstated to Membership:
Boomhour, J. Gregory, Dean Meredith College, Raleigh, N. C.
Browne, Edward T., Associate Professor of Mathematics, University of North Carolina.

Bush, Laurens Earle, Instructor in Mathematics, University of North Carolina.
Hatley, C. C., Assistant Professor of Physics, Duke University.
Jones, Edwin P., Duke University.
Jordan, Walter Edward, Assistant Professor of Chemistry, State College.
Snyder, Lawrence H., Professor of Zoology, State College.
Wright, W. T., Professor of Physics, North Carolina College for Women.
Yocum, L. Edwin, Professor of Botany, North Carolina College for Women.

The recommendations of the Executive Committee were adopted by sections. The report of the Executive Committee was adopted.

The Auditing Committee reported that it had examined the financial accounts of the Secretary-Treasurer covering the period May 7, 1927, to April 25, 1928, and found them correct.

The report was accepted and the Treasurer instructed to print the financial statement.

The Treasurer's report was called for and presented as follows:

Financial Statement

Receipts		Expenditures	
Balance on hand, May 7, 1927	$630.37	Stationery and postage	$34.93
Dues, for		Printing, mimeographing, and multigraphing	66.97
1927	80.00	Telegrams and phone calls	3.44
1928	262.00	Journal of the E. M. S. S.	200.00
1929	4.00	Clerical assistance	43.65
Initiations	102.00	High School Science Prize	20.00
Chemists' programs	5.00	Expenses of representative to deliver prize	3.00
Allotments from A. A. A. S. (1928 allotments still due)	3.00	Ribbons and badges for the Davidson meeting	6.15
Interest on savings account.	17.89	Sec'y-Treas. commission	44.00
	$1104.26	Dues refund to Sec'y-Treas.	2.00
		Dues refund to C. W. Edwards (from advanced initiation fee for student)	2.00
		Refund to A. A. A. S.	.50
			$426.64
		To balance	677.62
			$1104.26

Comparison

	1926-27	1927-28
Savings account	$441.02	$458.91
Checking account	189.35	184.71
Cash on hand		34.00
	$630.37	$677.62
To balance	47.25	
	$677.62	

The above report was made as of April 25, 1928.

Submitted by

H. R. Totten, *Secretary-Treasurer.*

Audited by

A. W. Hobbs,

J. B. Derieux.

The Treasurer's report was accepted.

The Nominating Committee made the following nominations:

President, J. S. Holmes, State Forester, North Carolina Department of Conservation and Development.

Vice-President, Miss Mary Petty, North Carolina College for Women.

Additional member of the Executive Committee for three years, F. A. Wolf, Duke University.

These were elected by acclamation.

The Resolutions Committee submitted the following resolutions:

Section I

"The Academy mourns the loss by death of Mr. R. W. Collett, a member of the Academy since 1910. Mr. Collett served the state for years as Director of the Branch Experiment Station at Swannanoa and at Willard, North Carolina, and thus took a leading part in the establishment and management of the research of the State Department of Agriculture and of the Agricultural Experiment Station.

"We deeply mourn his passing from among us, and hereby give this brief testimony of appreciation of his work in the conservation and development of our natural resources."

Section II

"Whereas the University of North Carolina and the people of Chapel Hill have done so much to make the twenty-seventh annual meeting of the North Carolina Academy of Science successful, (1) by the provision

of comfortable places for the exchange of reports of scientific discoveries, (2) by the preparation of instructive exhibits, (3) by the provision of entertainment by the University and in the homes of the people, Be it therefore resolved that we extend to them our deepest appreciation for these courtesies."

J. P. GIVLER
F. A. WOLF
LULA G. WINSTON, *Committee.*

The resolutions were adopted by a rising vote.

The following resolution in regard to the McNary-McSweeney Forest Research bills at that time before Congress was presented and adopted:

"Whereas, we believe that Forest Research as planned in the McNary-McSweeney Forest Research bills (S. 3556 and H. R. 12878) will be of very great value to the Forestry movement throughout North Carolina and the South; and

"Whereas, the U. S. Senate has passed the McNary bill (S. 3556), which is now before the House of Representatives; and the House committee on Agriculture has favorably reported the McSweeney bill which is now on the House Calender; and

"Whereas, a resolution has been introduced in the House of Representatives by Congressman McSweeney to give the Forest Research bill a definite position in the House Calender;

"Be it resolved by the North Carolina Academy of Science in annual meeting assembled, that it earnestly urges the members of Congress from North Carolina, and the members of the Rules Committee of the House to authorize the consideration of the McSweeney Forest Research bill (H. R. 12878) by the House of Representatives during the present session of Congress; and

"Be it further resolved that copies of this resolution be sent to the North Carolina members in Congress; to the members of the Rules Committee of the House, to Congressmen Haugen, Chairman of the House Committee on Agriculture, and to Congressman McSweeney, and to Congressman John Q. Tilson."

The following resolution in regard to a study of the taxation of forest lands was presented and adopted:

"Whereas the United States Government has appropriated funds for the initiation of a study of the taxation of forest lands in relation to the production of timber and local taxation generally, and

"Whereas the State of North Carolina has a well-organized and

efficient Forestry Division in its Department of Conservation and Development; and

"Whereas the North Carolina General Assembly of 1927 authorized the formation of a State Tax Commission to study the present system of taxation in North Carolina with a view to recommending desirable changes; Therefore be it

"Resolved that the North Carolina Academy of Science urge the United States Forest Service to take advantage of the special advantages offered for a study of the taxation of timber lands in a southern state, and seriously consider North Carolina as the southern state in which to make this study. And be it further

"Resolved that the Secretary be instructed to send a copy of this resolution to the Chief Forester of the United States Forest Service, Washington, D. C."

A note of greetings from Dr. E. W. Gudger was read to the Academy. The Secretary was instructed to send the greetings of the Academy to Dr. Gudger.

The following committees for the year 1928–1929 were appointed:

Committee on High School Science—R. N. Wilson of Duke University, chairman; B. N. Wells of State College, secretary; C. M. Heck of State College, C. E. Preston of the University of North Carolina, Bert Cunningham of Duke University, H. R. Totten of the University of North Carolina.

The business meeting of the Academy was adjourned at 4:30 p.m., and the rest of the afternoon was given over for tours of the exhibits.

The Academy reconvened at 8:00 p.m. with Vice-President Porter presiding. W. C. George, President of the Elisha Mitchell Scientific Society, welcomed the Academy to the University with the following words:

"Mr. President, Fellow Members of the North Carolina Academy of Science, Ladies and Gentlemen:

"Forty-five years ago next autumn a small group of young scientific men then in this University met together and organized a society, which they called the Elisha Mitchell Scientific Society in honor of a former member of this faculty. Of the original group of men who founded the society only Dr. Francis P. Venable, the first president of it, survives the passing of the years, but the organization that they founded continues with unabated vigor to serve the purpose for which they brought it into being. These men were living in a period shortly following the "re-

construction" era and the reopening of this University. They were trying to rehabilitate a struggling college in a disorganized and impoverished section of our country. They were acutely aware of the existing intellectual aridity and they organized the Mitchell Society to be an oasis in the desert, so that their thirst for knowledge might not go unquenched and so that they might live as scientists in an isolated community and keep alive the lamp of learning in the South.

"Their names are honored names in the roster of our faculty and the organization that they founded has been a potent influence in the intellectual life of this University and of the nation. The impetus that it gave to scholarship stimulated the formation somewhat later of other scholarly groups to serve men in the fields of learning other than the natural sciences. And members of the Mitchell Society were largely instrumental in the formation twenty-seven years ago of the North Carolina Academy of Science, which was to be an inspiration and a stimulus to the scientific men of the whole state such as the Mitchell Society had been to those of this University. That its formation was a significant event is evident when one senses the vigor of the scientific spirit that prevails at these annual meetings. The contributions to science that have been presented at the annual meetings of the Academy are of significant value, and many of us are aware of the intellectual stimulus supplied by the North Carolina Academy of Science in our individual lives and in the life of the state.

From time to time since its organization the Academy has met here in Chapel Hill, and this year the Elisha Mitchell Scientific Society and the University again have the opportunity and the honor of being its hosts. We people here look upon this meeting as an important event in the year's schedule and we look upon your individual coming as a pleasant occasion. As president of the Mitchell Society and in behalf of the President of the University, who is unable to be here at this time, I have the happy privilege of welcoming the members of the North Carolina Academy of Science to the University and to Chapel Hill."

Vice-President Porter responded for the Academy, and then presented President Bell, who delivered the presidential address on "Some Approaches to Fundamental Theory of the Physical Sciences." After this address an informal social hour was held in the social rooms of the Episcopal Parish House.

The Academy convened in sections Saturday morning, with President Bell presiding over the general-section group, P. M. Ginnings over the chemists, W. W. Rankin over the mathematicians, and J. M. Douglas over the physicists.

The following group officers were elected for the year 1928–29: Chemistry, L. G. Willis of State College, chairman; L. B. Rhodes of the State Department of Agriculture, secretary; A. S. Wheeler of the University of North Carolina, councillor. Mathematics, J. W. Lasley, Jr., of the University of North Carolina, chairman; W. W. Elliott of Duke University, secretary. Physics, W. T. Wright of the North Carolina College for Women, chairman; C. C. Hatley of Duke University, secretary.

The following papers were presented. Those marked with an * appear in full in this issue; those marked x are abstracted in this issue; for those unmarked no abstracts were received; those marked † were presented by title only.

GENERAL SECTION

The Mississippi Flood's Effect on the Soil Fertility of the Valley. COLLIER COBB, University.

**Some Effects of the Injection of Pituitrin into the Albumen of Hen Eggs* (Lantern). BERT CUNNINGHAM and W. STANFIELD, Duke.

**Two New Terrapins of the Genus Pseudemys from the Southern States.* C. S. BRIMLEY, Museum.

**Quality of the Surface Waters of North Carolina.* E. E. RANDOLPH, State.

x*Typical Structures of Central Appalachian Area and Their Relation to Topography* (Lantern). W. F. PROUTY, University.

x*The Origin of Folded Mountains* (Lantern). GERALD MACCARTHY, University.

The Animal Ecology of a North Carolina Sound (Lantern). Z. P. METCALF, State.

**Spore-forming, Gas-producing Aerobes in Water.* ROY J. CAMPBELL, Salem.

x*A Method for Growing Yeast Ascospores for Class Use* (Microscope). I. V. SHUNK and L. A. WHITFORD, State.

**Cell Behavior in the Regeneration of Sponges from Dissociated Cells.* H. V. WILSON and J. T. PENNEY, University.

**Interspecific Grafting using Sponge Cells.* M. W. DELAUBENFELS, Carnegie Institution.

The Earth's Magnetic Field. J. B. DERIEUX, State.

The Brown Mountain Light. A. A. DIXON and J. B. DERIEUX, State.

x*Rainfall Characteristics of North Carolina.* F. M. BELL, University.

Progress in the Conservation of Petroleum. Oscar R. REINHOLT, Guilford.

**Iodine in North Carolina Public Water Supplies.* E. E. RANDOLPH and J. W. PERRY, State.

†*Reproductive Structures of Dionaea muscipula* (Lantern). H. L. BLOMQUIST, Duke.

Observation on Mating of Copepods. L. L. HILL, University.

x*Genetic Evidences for Diploid Males in Hymenoptera.* MRS. P. W. WHITING, Catawba.

x*Sex Anomalies in the Genus Megachile* (Lantern). T. B. MITCHELL, State.

Concerning Entomogenous Fungi. FREDERICK A. WOLF, Duke.

A Remarkable Case of Mutualism between Fungi and Scale Insects. J. N. COUCH, University.

Schizophyllum commune Attacking Sweet Potatoes (Lantern). R. F. POOLE, State.

x*Soil Age and its Possible Significance in Geology.* W. B. COBB, State.

x*Early Italian Maps of American Shore Lines.* COLLIER COBB, University.

**Abnormal Embryos of Oats and Wheat* (Lantern). LUCILE SHARPE, N. C. C. W.

x*Structural Anomalies in Embryos of Maize* (Lantern). GEORGE S. AVERY, JR., Duke.

x*Variation in our Native Ornamental Flowering Trees.* W. C. COKER, University.

A New Species of Pyxidanthera (Lantern). B. W. WELLS, State.

Relation of Capillary Cavities in the Jungermanniaceae to Absorption and Storage of Water. H. L. BLOMQUIST, Duke.

x*Our Common Mosses.* PAUL M. PATTERSON, Davidson.

x*Progress in the Prevention of Covered Smut of Wheat with Copper Carbonate in North Carolina* (Lantern). G. W. FANT, State.

x*Parasites of North Carolina Amphibians* (Lantern). FRED J. HOLL, Duke.

x*The Devono-Mississippian Black Shales of Virginia and Tennessee.* JOEL H. SWARTZ, University.

x*A Cretaceous Sandstone Quarry near Kinston, North Carolina.* J. L. STUCKEY, State.

†*Minerals of a Biotite Schist Quarry near Spruce Pine, North Carolina.* HARRY T. DAVIS, Museum, and J. L. STUCKEY, State.

†*Structural Relationship of the Triassic Basins of Eastern North Carolina* (Lantern). J. F. PROUTY, University.

x*Cultivation of American Peppermint (Mentha piperita) in North Carolina* (Lantern). E. V. KYSER, University.

x*Cultivation of Bergamot Mint* (*Mentha citrata*) *in Chapel Hill.* H. R. TOTTEN and E. V. KYSER, University.

x*Japanese Plants around Chapel Hill.* COLLIER COBB, University.

Fresh Water Algae of Wake County. MARGARET LINEBERRY and W. L. POTEAT, Wake Forest.

†*Ecology of Parasites in Turtles* (Lantern). DEAN W. RUMBOLD, Duke.

x*Some X-Ray Studies of Fossils.* JOEL H. SWARTZ, University.

EXHIBITS

Exhibits of Human Embryology. W. C. GEORGE, University.

Demonstration of 11 mm. Human Embryo (Microscopes). O. C. BRADBURY, Wake Forest.

Wild Flower Show. Department of Botany, University.

A Mushroom Cellar. H. R. TOTTEN, University.

Early Embryogeny of Fishes and Frogs. SELMA M. LEE, L. L. HILL, and J. L. BAILEY, University.

MATHEMATICS SECTION

x*On Polar Curves as Covariants.* J. W. LASLEY, JR., University.

x*A Formula for Computing Transvectants in Non-Symbolic Notation.* L. E. BUSH, University.

x*A Proof of the Jacobi Condition for a Particular Problem.* ERNEST L. MACKIE, University.

Certain Properties of Rotations in Space. R. C. BULLOCK, University.

Homographies. ARTHUR S. WINSOR, University.

x*On the Signature of a Quadratic Form.* EDWARD T. BROWNE, University.

x*Some Third Order Determinant Theorems by Vector Methods.* MARIE TURNIPSEED, Duke.

x*Some Types of Plane Cubic Curves.* JAMES BOYD, Duke.

x*The Cylindrical and Spherical Worlds of Einstein and De Sitter.* ARCHIBALD HENDERSON, University.

PHYSICS SECTION

x*The Fraction of the Mass of Various Types of Springs Accelerated in Simple Harmonic Motion.* GYFFORD D. COLLINS and O. B. ADER, Duke.

x*A Method of Detecting Small Adiabatic Changes.* E. K. PLYLER, University.

Values of the Earth's Magnetic Field at Raleigh, North Carolina. H. A. FISHER, State.

x*The Formation of Atomic Negative Ions in Mercury Vapor.* WALTER M. NIELSEN, Duke.

x*On Some Ultra-Ionization Critical Potentials in Mercury Vapor.* R. D. POTTER, Duke.

x*Critical Potentials Below 4.7 Volts for Negative Ion Formation in Mercury Vapor.* WALTER M. NIELSEN, Duke.

Absorption Spectra of Some Organic Dye Solutions—Temperature Effect. (Lantern). W. E. SPEAS, Wake Forest.

The Sensitive Lines in the Nickel-Copper Alloy Spectrum. DONALD KIRKPATRICK, Duke.

x*Combination Frequencies of the Infra Red Spectrum of Quartz.* E. K. PLYLER, University.

NORTH CAROLINA SECTION OF THE AMERICAN CHEMICAL SOCIETY

Electrometric Titration of Nickel Solution. H. D. CROCKFORD and J. D. MCCLUER, University.

Plant Response to Manganese on Some North Carolina Soils. L. G. WILLIS, State.

Cymene-2-dithiocarboxylic Acid. A. S. WHEELER and C. L. THOMAS, University.

Two Component Systems, Salycilic Acid and a Nitrotoluene. H. D. CROCKFORD and F. W. ZURBURG, University.

The System CaO-As_2O_5-H_2O. A. T. CLIFFORD and F. K. CAMERON, University.

The System CaO-P_2O_5-SO_2-H_2O. W. W. MEBANE and F. K. CAMERON, University.

Acid Mercerization. W. B. SELLARS and F. C. VILBRANDT, University.

The Reaction between Acetylacetone and Phenylsemicarbazide. A. S. WHEELER and R. D. NORTON, University.

Oxidation-Reduction Potential Study of Indigo Solutions. H. D. CROCKFORD and O. B. HAGER, University.

E. M. F. Studies of Battery Metals. H. D. CROCKFORD and H. G. HOLROYD, University.

The Silicate Minerals and Water. MAUDE WEBSTER and F. K. CAMERON, University.

Sulfur dioxide-Potassium Permanganate Reactions. F. C. VILBRANDT, University.

The System $CuSO_4$-$FeSO_4$-H_2O. H. D. CROCKFORD and F. K. CAMERON, University.

Cymylene-2, 5-diamine. A. S. WHEELER and R. W. BOST, University.
Electrometric Determination of Fluorine. H. D. CROCKFORD and H. G. GALLENT, University.
Lithium Chloride-Ammonia Complexes. S. C. COLLINS and F. K. CAMERON, University.
5-Bromo-m-4-xylidine. A. S. WHEELER and R. E. THOMAS, University.
Road Tar Emulsions. W. M. LOFTON and F. C. VILBRANDT, University.

The following abstracts have been received:

Typical Structures of Central Appalachian Area and Their Relation to Topography. W. F. PROUTY.

In the Central Appalachian Area, west of the great belt of outcropping, massive limestones and dolomites, the surface rocks are largely thinner-bedded limestones, shales, and sandstones. These have readily folded under lateral earth pressures and have been little faulted. Under these conditions we have the maximum relationship between erosional topography and geologic structure. In all folds, after erosion has cut through the heavy sandstone arches, the anticlines tend to become depressions and the synclines to become elevations. In some of the larger geanticlines of the area, as Patterson Creek Mountain, Hardy County, West Virginia, this correspondence is so perfect that a longitudinal structural profile of the great fold can be drawn from a study of a distant sky-line photograph. The same tendency of erosion to form anticlinal valleys and synclinal hills applies equally well to longitudinal or to transverse folds.

In many of the larger anticlinal valleys where the folds have been overturned and dips are steep, as in the eastern portions of Hampshire and Hardy Counties, West Virginia, drag folding and fracture cleavage of the less competent beds make it possible to readily determine the direction of the axis of fold from the point of observation.

The Origin of Folded Mountains. GERALD R. MACCARTHY.

Almost all of the great mountain systems are formed of a series of folded and faulted sedimentary rocks, and show evidence of great compression on one or both sides. In almost every case one side of a fault or fold is found to have apparently over-ridden the other, and the assumption is generally made that such was actually the case. Experimental work with plastic models shows that underthrusting may, under certain conditions, take the place of overthrusting, and on comparing the

conditions under which mountains must have been formed with these it appears that many mountain ranges may be under- rather than over-thrust.

A Method for Growing Yeast Ascospores for Class Use. I. V. SHUNK and L. A. WHITFORD.

A pure culture of *Saccharomyces cerevisiae* is isolated from a fresh cake of Fleischmann's yeast by means of dextrose agar plates. The medium used for isolation was composed of the following: 1000 cc. water, 3 grams meat extract, 5 grams sodium chloride, 10 grams peptone and 10 grams of dextrose. After isolation the yeasts are grown for several days on dextrose agar slants. Sterilized potato plugs in test tubes are then inoculated with the yeast from the agar slants, and after 10–14 days ascospores are found in the yeast growth on the potato.

Rainfall Characteristics of North Carolina. F. M. BELL.

This is a comprehensive investigation of annual rainfall and its distribution in North Carolina. The records of all rainfall stations in the state have been assembled, corrected and tabulated, and the mean annual rainfall computed for each station. A rainfall map of North Carolina has been prepared which illustrates the distribution of precipitation over the state for the 40 year period 1888–1927, inclusive. This map indicates that annual rainfall is well distributed over the state, varying from 49 to 55 inches in the coastal plain section, 43 to 50 inches in the piedmont section, and 38 to 83 inches in the mountain region. The lowest annual rainfall in the state occurs at Asheville in the French Broad Valley, and the highest occurs at Highlands in Macon County. The rainfall varies more or less in amount from year to year, but a study of the records of many stations indicates that extreme variations from the mean are uncommon. A preliminary study of monthly rainfall shows that the month of maximum rainfall is July and the minimum amount occurs in November, and that there is heavy spring rainfall in the western section of the state.

Genetic Evidence for Diploid Males in Hymenoptera. ANNA R. WHITING.

Four allelomorphs affecting eye color and three pairs of allelomorphs affecting wing form and venation, none linked, are studied from the point of view of the method of their inheritance by biparental males in *Habrobracon juglandis* (Ashmead). A female homozygous for one or more recessive factors when crossed to a male carrying allelomorphs to these

factors produces, in addition to recessive haploid sons and dominant diploid daughters, sons which have all dominant characters like their sisters. In crosses where females are homozygous for some recessive and some dominant factors and males possess allelomorphs the biparental sons are entirely dominant, showing that they have some factors from each parent. When three of these factors affect one structure (the wing in this case) if one recessive and two dominants are contributed by one parent, their allelomorphs by the other, this structure in biparental males shows all the dominant characters. From these results it is concluded that biparental males are diploid, at least for the four chromosomes that can be identified genetically. The few daughters of these males are usually abnormal and sterile. It is suggested that they may be triploid.

Sex Anomalies in the Genus Megachile. THEODORE BERTIS MITCHELL.

A series of specimens of the genus *Megachile* (leaf-cutter bees) which are anomalous as to sex are described. In this genus sexual dimorphism is rather extreme, and such abnormal conditions are therefore conspicuous. Previous records of such conditions in this genus have been few, there being published accounts of gynandromorphic individuals of only three species, together with accounts of two species in which it is supposed that the female is normally gynandromorphic. Thus the number of anomalous specimens in this series is remarkable, there being twenty-three specimens representing eleven species.

All of these specimens are females in which the somatic characters normal to the male have been caused to appear, to a slight degree in some instances, to a very marked extent in others. In some of the specimens the appearance suggests a female abdomen glued to a male head and thorax, and these bear a strong resemblance therefore to frontal gynandromorphs. But intergrading characters indicate that most or all of the specimens described would be better designated as intersexes. In all of the specimens the apex of the abdomen is female in character, and apparently the genitalia are as in the normal female. Five of the specimens (four species) are from North America, and from widely scattered regions, and all of these are referable to well known Nearctic species. The remainder of the series was collected in South America, in Brazil and Paraguay, and only one known species is represented. However, with but two exceptions, there were either normal males or normal females of the intersexual specimens represented in the series, and these normal individuals are therefore described as new species, and the intersexual forms are referred to these new species.

Nothing definite is known as to the origin of these intersexes. Judging, however, from the various facts and theories regarding the origin of intersexual conditions in other animal groups, three possibilities become apparent. It is possible (1) that they are the result of parasitism, although there are no external evidences of such a condition, and no internal evidences in the single instance in which this was investigated. It is also possible (2) that some of these are true gynandromorphs which have arisen through some abnormality in the behavior of the chromosomes during somatic development. And (3) in certain of the forms there seems a rather strong likelihood that the females are normally gynandromorphic, as is the case in certain ants in which the male exhibits certain characteristics of the worker or soldier as the normal condition.

Soil Age and its Possible Significance in Geology. W. B. COBB.

A study of the Triassic area of North Carolina brings out the fact that none of the soils residual from the igneous intrusions of this area have reached maturity, while probably 85 per cent of those of the Pre-Cambrian areas have reached an advanced stage of development. Three distinct soil series are developed from the basic crystalline rocks of piedmont North Carolina. The younger series, the Iredell, is characterized by its high content of lime and magnesia, the lack of oxidation of its iron, and the shallow depth at which greenish disintegrated rock is encountered, usually from 24 to 28 inches. The intermediate soil, the Mecklenburg, shows less lime and magnesia, a more highly oxidized iron content, and a greater depth to weathered rock in which decomposition is much more evident than in the younger soil. The older soil, the Davidson, has lost the greater part of its lime and magnesia, its iron content is thoroughly oxidized, the subsoil extends to considerable depth, from 40 to 70 inches or more, and the weathered rock underneath is very highly decomposed and oxidized.

None of this latter soil is found in the Triassic area, the intermediate soil being the oldest soil found in this region, and the younger soil being by far the most extensive.

The rocks giving rise to these soils have in many instances probably been exposed to soil-forming agencies since the end of the peneplanation taking place during the Cretaceous period. From this it would seem that the time which has elapsed since then is necessary for the development of the intermediate soil and that the older soil, occurring in the Pre-Cambrian area, has been developing for a very much longer time, probably at least for several million years.

A few outliers of granite have been observed near the western border of the Triassic. These may have been monadnocks although they were possibly intrusions which have become exposed by the erosion of the overlying Triassic rocks. At any rate none of the soil occupying these outliers has developed beyond the Appling stage which is an early intermediate stage in the development of soils from acid crystalline rocks.

From these observations the idea has developed that the degree of development of the derived soils may be used as an indication of the age of geological formations. Applying this to the belt of granite east of Raleigh on which the soils have not reached maturity it seems easily possible that this granite intrusion may have resulted from the same general igneous disturbance that produced the dykes cutting through the Triassic. Another possibility is that it was associated with the disturbance which produced the fault trough in which the Triassic beds accumulated. The most advanced soils of the granite area are a little further advanced than those of the Triassic. Of course the rate of weathering of the two rocks may be different.

On either side of the granite belt occur highly metamorphosed rocks, generally considered Pre-Cambrian, which are almost entirely occupied by very old soils. That these metamorphic rocks are older than the granite is also evident from the large number of granite pegmatite dykes intruding into the gneiss from the granite, at least on the western border of the granite mass.

From these few observations it seems that a study of soil age may throw light on the age of geological formations or at least on the length of time during which the rocks have been exposed to weathering.

Early Italian Maps of American Shorelines. COLLIER COBB.

Photostats of sixteen maps engraved by Antonio Francisco Lucini. Several from the collection of Sir Robert Dudley, the rest obtained in ports around the Mediterranean, dating from the third expedition of Columbus fitted out by Amerigo Vespucci exploring the coast of Venezuela (Guiana) in 1499, and including maps made as late as 1661 extending even to the northward of Newfoundland. These maps show the character of the shoreline in even greater detail than the Portolano maps. In many cases they give soundings and mark the variation of the compass; and they are the earliest wind and current charts of which we have any knowledge.

Structural Anomalies in Embryos of Maize. GEORGE S. AVERY, JR.

In an examination of several thousand seedlings and numerous embryos of maize, many structural abnormalities have been noted. These consist of a double growing point, a cleft in the top of the cotyledon, more than the usual two bundles in the coleoptile, and the presence of a bud in the axil of the coleoptile.

Variation in our Native Ornamental Flowering Trees. W. C. COKER.

Attention was called to the great variation in both color and size in flowers of native dogwood (*Cornus florida*) in Chapel Hill. Forms occur from pure white to deep reddish pink. River plum (*Prunus americana*) has individuals here that are far more showy in flower than the type. One of these has flowers in large dense clusters reminding one of a delicate snowball; others may be light pink and very floriferous, giving an effect equal to that of the finest Japanese cherries. Many variations occur in the leaves of the evergreens, *Magnolia grandiflora* and the common holly, and the latter may have yellow berries instead of red.

Our Common Mosses. PAUL M. PATTERSON.

There have been a total of 98 species from 54 genera of mosses found in the past three years by the writer mainly from Chapel Hill, N. C., but also from near Staunton, Va., Davidson, N. C., and Chimney Rock, N. C.

Some work was begun on the study of moss stem structure. An interesting variation was noted in *Leucobryum glaucum* in that in each cell throughout the gametophytic stem there were several pores of considerable size that formed open communications between adjacent cells. The cells have protoplasmic content, and the pores probably facilitate water transportation.

Progress in the Prevention of Covered Smut of Wheat with Copper Carbonate in North Carolina. G. W. FANT.

Losses resulting from the covered smut diseases of wheat in North Carolina come about both from a reduction in yields, and also from the inferiority of smutted wheat when used for milling purposes. The covered smut disease, which is of state-wide occurrence, can be prevented by the dry copper carbonate dust treatment of the seed, since the disease is seed borne.

In the fall of 1927, seed treatment demonstrations were given in the principal wheat producing counties of the state, which were attended by

several hundred wheat growers. Publicity was given to the new treatment also by means of newspaper articles and mimeographed sheets describing the new treatment. At the end of the season estimates as to the quantity of copper carbonate dust used by growers was obtained from copper carbonate dealers, which indicated that sufficient dust was secured by growers to treat seed wheat for from twelve to fourteen thousand acres. One power driven treating machine installed by a flour mill operator treated in excess of eight hundred bushels of seed wheat following the cleaning process for the removal of foreign seeds. While seed treatment in 1927 was practiced principally by the growers, themselves, power driven machines installed at milling plants offer a better opportunity for treating seed wheat with a minimum expenditure of labor.

Parasites of North Carolina Amphibians. FRED J. HOLL.

During the months of October and November, 1927, the parasites of *Triturus viridescens* Rafinesque were studied. Three stages in the life cycle of this salamander were found: (1) the aquatic stage; (2) the terrestrial; and (3) a transitional stage during which time the salamander was living in the water but had some of the terrestrial characters. The land stage showed an average infestation of 4 parasites per host; the transitional stage was 4.2; and the aquatic newts had 11.6 parasites per host. *Acanthocephalus* sp., *Cosmocerca dukae* Holl, and *Opisthodiscus americanus* Holl, were limited to the aquatic stage.

The number of helminth parasites present in the cricket frog, *Acris gryllus* (Le Conte) were studied from March 1927 to April 1928. This frog had slight infestation at the beginning of the breeding season and the infestation increased during the time of sexual activity. Following the breeding season the number of parasites decreased until in autumn, when the frogs collected were free of helminth parasites.

The Devono-Mississippian Black Shales of Virginia and Tennessee. J. H. SWARTZ.

The Devono-Mississippian boundary in central and southeastern United States is concealed by a series of beds, chiefly black shales, whose relationships to each other and to the Devonian and Mississippian systems have long been in doubt. Two of the most interesting of these are the Chattanooga black shale of Tennessee and the Big Stone Gap shale of Virginia. If their ages could be determined the problem would be solved for Tennessee and Virginia and the way thus opened for the solution of the question in the whole of the eastern United States.

In 1921 and 1922 the writer traced the Chattanooga shale from Chattanooga, Tennessee, to Cumberland Gap, Tennessee, and showed it to consist of three members: (1) an upper black shale, (2) a middle gray shale, and (3) a lower black shale. In 1923 Ulrich and Stose named the Big Stone Gap shale at Big Stone Gap, Virginia, and Stose traced it, supposedly, to Mendota, Virginia, within twelve miles of known beds, but lost it there. In 1925 the writer was able to carry it northeast of Mendota and to bring the known beds south until they overlapped the black shales identified by Stose as Big Stone Gap. He thus proved that the black shale at Mendota was Devonian in age. In 1926 he traced the Big Stone Gap shale from Big Stone Gap to Cumberland Gap and showed that the true Big Stone Gap was merely a northward continuation of the Chattanooga shale, with which it was thus identical, and that it showed the same three-fold subdivision.

Last year, 1927, the writer traced the Chattanooga shale from Big Stone Gap via Sneedville, Tennessee, to Clinch Mountain. He also followed the Devonian and Mississippian beds and the black shale at Mendota identified by Stose as Big Stone Gap shale southward through Virginia also into the Clinch Mountain area. He was thus able to prove the following facts:

1. The black shale identified by Stose as Big Stone Gap is not Big Stone Gap at all. It is older than the Big Stone Gap (Chattanooga) shale, which it underlies, and from which it is separated by a considerable thickness of Chemung beds.

2. The Chattanooga shale can be traced to Klondyke, Tennessee, up to which point it shows its characteristic three-fold division. Beyond that point it can be traced only after more extensive field work.

3. A characteristic Mississippian fauna was found in the middle member of the Chattanooga at Rutledge and Sneedville, Tennessee. The upper two-thirds of the formation is thus proven Mississippian in age. The lower third is probably Mississippian, although more field work is needed to settle this point.

4. Some evidence was found that there is no true break between the Devonian and the Mississippian, but that Devonian faunas persisted in some areas after Mississippian faunas had appeared in others. If substantiated by further work this will cause important changes in our ideas of what constitutes a geological period.

Some X-Ray Studies of Fossils. J. H. SWARTZ.

A series of x-ray photographs were made of a considerable number of fossils, especially of Foraminifera. It was found that the internal structure of the larger forams could be very easily determined in this way. Since several hundred foraminifera can be photographed at once, with exposures of from 1 to 2 seconds, a very rapid and simple method is thus provided for the investigation of their internal anatomy.

The method is not yet available for the study of the smaller forms since their internal structures are blurred and partially concealed by the coarseness of the silver grains in the finished negative. Experiments are being carried on in an attempt to discover some method of taking enlarged x-ray photographs.

A series of photographs of larger fossils showed that excellent results could be obtained where the fossil had been replaced by silica or, in some cases, pyrite. The ordinary fossil, however, has a filling too closely allied chemically to the shell to permit the necessary contrast for good photographs. Efforts were made to produce an artificial contrast by staining, but so far they have met with little success. The experiments, however, are being continued.

A Cretaceous Sandstone Quarry near Kinston, North Carolina. JASPER L. STUCKEY.

Beginning about one mile directly east of Kinston and extending for a mile or more in a general eastward direction along a steep terrace scarp on the north bank of Neuse River is an interesting outcrop of well consolidated sandstone. Approximately 2 miles east of Kinston is an old quarry from which this stone was taken for foundation work in the old railroad bridge across Neuse River nearby. The outcrop has since been prospected as a source of ballast material by the Norfolk and Southern Railroad. Under modern conditions the stone has little promise of further use, but the old quarry is of interest since it indicates the extent to which our forefathers made use of the available natural resources of each community.

The outcrop which is five to six feet thick, is found about the 50 foot contour line or approximately 30 feet above the level of Neuse River at that point and from $\frac{1}{4}$ to $\frac{1}{2}$ mile north of the river. At the base is a conglomerate bed about 1 foot thick composed of water worn quartz and phosphatized pebbles up to an inch or more in diameter. This conglomerate contains numerous worn shark's teeth, a few shell fragments and small amounts of glauconite. Above this conglomerate,

which rests unconformably upon a fine grained argillaceous sand are 4 to 6 feet of medium to fine grained gray colored quartz sandstone interbedded with thin layers of black to gray clay or mud. This is in turn overlain by 3 to 10 feet of Pleistocene sands of the Wicomico terrace formation.

The microscope shows the sandstone layers to be composed of angular grains of quartz about 1 to 2 mm. in diameter. Associated with the quartz are small amounts of feldspar chiefly albite and oligoclase, with occasional grains of microcline. Scattered uniformly through the sections are rounded grains of glauconite about ½ mm. in diameter. Small amounts of sericite tourmaline, and magnetite are present. These coarser grains are embedded in a ground mass too fine to be identified by the high power of the microscope. Scattered through the section are small amounts of secondary silica which cements the mass.

Crushing strength tests made by James Fontaine of the Engineering Experiment Station at State College show the rock to have a strength of 6,400 pounds per square inch.

The outcrop occurs in an area mapped by L. W. Stephenson[1] as Cretaceous. The general character of the material conforms more nearly with the Eocene as mapped further east and south. This outcrop probably represents a part of a small lenticular mass of the Trent River formation such as is found at several places in the upper coastal plain region.

Cultivation of American Peppermint (Mentha Piperita) in North Carolina. E. V. KYSER.

Joseph Slabaugh, a Mennonite truck farmer introduced mint cultivation in North Carolina in 1918. The initial plantings were from a cigar box of roots obtained from Indiana. At present there is about seventy-five acres under cultivation in this district. The farms lie two miles east of Moyock, Currituck County, on the edge of Dismal Swamp.

The young plants are set out in April or May, in rows three to four feet wide and about twenty inches in the row. Cultivation by ploughing and hoeing is continued weekly until the runners become too numerous to permit further working, after which the fields are weeded by hand.

Usually two cuttings are obtained; one in July and one in September. A clover mower with a buncher is used. The herb is sun dried for a few days and then distilled. The spent herb is dried and used as a

[1] North Carolina Geology and Economy Survey, Vol. III.

cattle feed. The chief pests are crab grass, smart grass, raw weed, pea weed, jimson weed and wormseed. The project which is being carried on through a research grant from the American Pharmaceutical Association, will be extended over a three-year period.

The Cultivation of Bergamot Mint (Mentha Citrata) in Chapel Hill. H. R. TOTTEN and E. V. KYSER.

A three-year survey has been made of the cultivation of bergamot mint at Chapel Hill. The problem has been considered with the idea of determining the advisability of planting bergamot mint as an agricultural crop. A wild form of escaped mint has been cultivated along with the cultivated variety under the same conditions. The results have been as follows: the wild herb yields 0.1 per cent oil, the cultivated wild form 0.23 per cent oil, and the cultivated form 0.48 per cent oil. The distilled oils from the three forms are comparatively the same in chemical composition. A typical analysis of the oil is as follows: color, water white; acid number, 0.35; saponification number 141.17; acetalization number 188.30; free linalool, 16.89 per cent; combined linalool, 43.42 per cent; total linalool, 60.31 per cent; specific gravity at 20°C., 0.9033; index of refraction at 20°C., 1.4580; angle of rotation, −8.50°; soluble in 70 per cent alcohol, 1 in 2 volumes of alcohol.

The acreage under cultivation has not been sufficiently large to determine satisfactorily the amount of oil which may be obtainable; however, experiments which are being carried on this year on larger plots should give somewhat conclusive information relative to the yield of herb and oil per acre.

This project is made possible by a grant from the Research Fund administered by the Graduate School of the University. The complete paper will be published in an early number of the *Journal of the Elisha Mitchell Scientific Society.*

Japanese Plants Around Chapel Hill. COLLIER COBB.

William A. Graham (A.B. University of North Carolina, 1824), Secretary of the Navy, 1850–1853, sent Commodore Matthew Galbraith Perry to Japan in 1852.

James Dobbin (A.B. University of North Carolina, 1832) Secretary of the Navy 1853–57, received the report of the returning Perry, who had made a commercial treaty with Japan in 1854.

Dr. James Morrow of Charleston, agriculturist of the expedition, made the collection of plants submitted to Asa Gray and described by Pro-

fessor Gray with the assistance of Mr. Sullivant, Dr. Harvey, and others at Harvard College.

The "Narrative of The Expedition" was written by Dr. Francis Lister Hawkes (A.B. University of North Carolina, 1815).

Lieutenant James Iredell Johnston, U. S. N., a North Carolinian, executive officer of the *Powhatan*, on which the first Japanese Embassy made their voyage as far as Panama in 1860, brought with him a few living plants and the seeds of many more. Nearly all of these found their way to Chapel Hill. They were set out and planted in and around the campus of the University where most of them flourished, producing a dense undergrowth on the campus until cleared out by order of President George T. Winston in 1891 and 1892.

In 1877 Dr. Kemp P. Battle showed me *Shortia* from Japan growing just south of the campus, and toward the end of that same summer I saw a different species of *Shortia* growing in the mountains of North Carolina. Professor Asa Gray told me in 1886 that the plants of Japan were strikingly like those of North Carolina all the way from the region around Wilmington to the mountains of the western and northwestern parts of the state. A list will follow later.

[Editor's note: It may be of interest to readers to know that the Japanese *Shortia* mentioned above is still in vigorous growth in the woods where planted. There is a considerable patch of healthy plants that bloomed abundantly this spring. If they were planted about 1860 as seems probable, the colony is now approaching seventy years of age and may be considered thoroughly naturalized. They are growing in a secluded place by a brook in an upland forest that has not been disturbed for at least a century and a half, if ever. W. C. C.]

On Polar Curves as Covariants. J. W. LASLEY, JR.

In the theory of algebraic plane curves the fact that polar curves are covariants is established by means of a detailed process of partial differentiation. This paper presents a proof of this well-known fact by means of the fact that the original curve is itself a covariant.

A Formula for Computing Transvectants in Non-Symbolic Notation. L. E. BUSH.

The r-th transvectant of two binary forms, u and v, of orders p and q is usually defined in terms of the Clebsch-Aronhold symbolic notation (see L. E. Dickson, *Algebraic Invariants*, p. 77). If the forms u and v be expressed in different sets of variables and the product uv be operated

on with a certain differential operator (see E. B. Elliott, *An Introduction to the Algebra of Quantics*, pp. 75, 78 et seq.) the result obtained will, after the two sets of variables are identified, be the r-th transvectant of u and v, except for a constant factor.

In this paper these operations are performed and the result is expressed as a formula for computing transvectants. It is shown that the r-th transvectant is a sum of products of other binary forms whose coefficients are selected in a definite manner from those of u and v. Each term in this sum consists of a form of order p-r times one of order q-r, making the order of the transvectant $p + q - 2r$. The formula, in addition to simplifying the work of computing transvectants, puts the concomitant in a form in which it can be more easily studied. The degree, weight, order, and index are easily found from the expression.

A Proof of the Jacobi Condition for a Particular Type of Problem. ERNEST L. MACKIE.

The question of minimizing the quotient of two simple integrals is considered. A set of differential equations and end values of the variables for a minimizing arc being given and the Euler-Lagrange equations as a first necessary condition being known, a proof is given that the Kneser envelope theorem and Jacobi Condition apply to this problem as to simpler ones in the Calculus of Variations.

On the Signature of a Quadratic Form. EDWARD T. BROWNE.

A real quadratic form in n variables can always be reduced, by means of a real linear homogeneous transformation on the variables, into a canonical form which involves only the squares of the variables. If the form is of rank r this canonical form involves exactly r coefficients different from zero. If P and N denote the number of positive and negative coefficients, respectively, in the canonical form, where obviously $P + N = r$, the difference $P - N = s$ is called the *signature* of the form. The four quantities P, N, r and s, of which only two are independent, are arithmetic invariants under *real* linear transformations.

Denoting by A_i the principal minor determinant of order i standing in the upper left hand corner of the matrix of the form and writing $A_0 = 1$, the variables can always be so numbered that no consecutive two of the numbers in the sequence

$$A_0, A_1, A_2, \ldots\ldots\ldots\ldots, A_r \tag{1}$$

shall vanish and $A_r \neq 0$. The form is then said to be *regular*. Gundelfinger has shown that if the form is regular the number N of negative

coefficients in the canonical form is exactly equal to the number of variations of sign in the sequence (1), where a vanishing term is given a sign at pleasure. Frobenius has shown that if $A_r \neq 0$, N can always be determined from the sequence (1) even when *two* consecutive A's vanish, but that this cannot always be done when *three* consecutive terms vanish.

In this paper a study is made of the case where $A_r \neq 0$ and two or three consecutive A's vanish. In the discussion use is made of only the simplest theorems on determinants. For the case where two consecutive A's vanish Frobenius' results are checked, while if three consecutive A's vanish it is shown that N can always be determined provided the adjacent A's have the same sign. The same methods are applied to a study of real *recurring* quadratic forms, and the results thus obtained are applied at once to the study of the discriminant of a real algebraic equation.

Some Third Order Determinant Theorems by Vector Methods. MARIE TURNIPSEED.

Several of the fundamental theorems on third-order determinants are proved by means of certain properties of the scalar triple product of vectors.

Some Types of Plane Cubic Curves. JAMES E. BOYD.

It can be shown that all cubics with a point of inflexion at infinity are symmetrical with a certain line. Call this line the x-axis in the rectilinear system of coordinates and all cubics may be written in the form:

$$y^2 = Ax^3 + Bx^2 + Cx + D$$

From this we may derive five cases according to the roots of $Ax^3 + Bx^2 + Cx + D$:

Case I. Three real and unequal roots. $\alpha < \beta < \gamma$.

Case II. One real and two imaginary roots. α and β imaginary, γ real.

Case III. Three real roots but two of them equal. $\alpha = \beta < \gamma$.

Case IV. Three real roots but two of them equal. $\alpha < \beta = \gamma$.

Case V. Three real roots and equal roots. $\alpha = \beta = \gamma$.

Thus, we may arrive at five projective types of cubic curves. There are about fifty metric types of cubics, but by a series of projections and sections we can carry any of them into one of the above five projective cases.

If we begin with the five projective cases and project to infinity different lines of intersection, the projection will in each case be one of the metric types of cubics. If all of the different ways in which lines may be drawn intersecting the projective types of cubics are considered, we can find all of the metric types of cubics, each projection giving a new cubic curve.

The Cylindrical and Spherical Worlds of Einstein and DeSitter. ARCHIBALD HENDERSON.

A technical explanation was given of the meaning of "the curvature of space," a conception needed for the understanding of the new conceptions of the universe put forward by Einstein and DeSitter as four-dimensional, space-time constructs. In 1917, Einstein proposed to consider the universe as closed but unbounded, the space being of an elliptical character. DeSitter later proposed a further generalization involving modification of the time element. The characteristic feature of Einstein's proposal is the assumption that matter throughout the universe be considered of uniform density, and that inertia is a function of matter, in conformity with the views of Ernest Mach.

Dr. Henderson compared the views of space and of space-time, with reference to the universe, of Newton, Einstein and DeSitter. The proposal of DeSitter is the most satisfactory of the three, leading to zero values for all the gravity-potentials at infinity, for all transformations; and furnishing the conception of a completely isotropic universe. Elaborate calculations carried out by Henderson showed that all the spaces considered were of constant curvature. He concluded his paper by presenting the results of the calculations of Kapteyn, Einstein, DeSitter, Lundmark and Silberstein, as well as some of his own, based upon Einstein's theory. He showed that if the mean density of matter in the universe is taken to be the same as that of the Milky Way, we shall have the following result: The radius of the resulting Einstein universe is one million times ten million times the distance from the earth to the sun.

The Fraction of the Mass of Various Types of Springs Which is Accelerated in Simple Harmonic Motion. GYFFORD D. COLLINS and O. B. ADER.

It has been known for some time that when a helical spring, from which a weight is suspended, is caused to execute simple harmonic motion, a fraction of the mass of the spring equal to $\frac{1}{3}$ is accelerated. The kinetic

energy of the system in this case is given by $\frac{1}{2}(M + m/3)q'^2$, in which M is the mass suspended from the spring, m is the mass of the spring, and $\dot{q}$ is the velocity of the vibrating masses.

In this paper an attempt has been made to arrive at the fraction of mass accelerated in springs wound in the form of a cone, inverted cone, truncated cone, inverted truncated cone, and double truncated cones.

For the spring wound in the form of a cone it is found that only $\frac{1}{4}$ of the mass is accelerated if the spring is suspended with the apex up, while $\frac{3}{4}$ is accelerated if the spring is inverted.

In the case of the last three types expressions are obtained in terms of the radii of the top and bottom of the springs which give the fraction of mass accelerated in each case, and from which the results for the helical and conical springs can be obtained.

The results have been obtained by the use of equations in differential geometry, and have been checked by potential and kinetic energy considerations. The effect of shear has been neglected, however. The work has been checked to some extent experimentally, but can not be completed until special springs can be made up.

A Method of Detecting Small Adiabatic Changes. E. K. PLYLER.

In some experiments of measuring infra red radiations by means of a thermopile, the galvanometer was unsteady at times. It was found that the movement of the galvanometer coil was due to small electric current produced by the thermopile. On protecting the thermophile from the changes of pressure in the air, the effect was not observed. Changes in the temperature of $\frac{1}{1,000,000}$ of a degree Centigrade can be detected by this method.

Combination Frequencies in the Infra Red Spectrum of Quartz. E. K. PLYLER.

Many observers have studied the infra red absorption bands of quartz and have found regions of intense absorption at about 9μ, 12.5μ, and 20μ and 26μ. The writer has considered these regions of absorption as the fundamental frequencies for the ordinary ray of quartz. By combining the fundamental frequencies six bands in the region from 3μ to 9μ are accounted for. Two bands not previously observed have been found at 2.72μ and 3.18μ. The frequencies of these two bands correspond to two combinations of the fundamental frequencies. This gives a total of twelve absorption bands for the ordinary ray of quartz extending from 2.72μ to 26μ. The frequencies of the observed bands correspond, with only small differences, to the calculated values.

The Formation of Atomic Negative Ions in Mercury Vapor. WALTER M. NIELSEN.

A beam of electrons was projected along the axis of a discharge tube, coaxially placed inside a solenoid which produced a magnetic field of 250 gauss. Negative and positive ion currents produced in a definite length of the beam were measured for different driving potentials by applying suitable potentials to electrodes on opposite sides of the electron beam. The total current was absorbed by an end plate, placed perpendicularly to the magnetic field. Secondary electron effects were eliminated by a 115 volt accelerating potential on the end plate. The curves giving the relationship between the ratio of negative ion to total current as a function of the driving potential show that: At a vapor pressure corresponding to saturation at 14°C., the probability of the capture of a slowly moving electron by a normal atom is small compared with the probability of the attachment of an electron to an excited mercury atom. The following critical potentials for negative ion formation were observed: 4.7, 5.3, 6.0, 7.3, 8.8, 9.3, and 11.4 volts.

Under the above conditions, a relatively small number of negative ions was observed at 2.3 and 2.7 volts. They are believed to be due to the mercury molecule and will be discussed in another paper.

Critical Potentials Below 4.7 Volts for Negative Ion Formation in Mercury Vapor. WALTER M. NIELSEN.

The experimental apparatus and procedure is given in another paper presented at this meeting.

At higher vapor pressures, the following critical potentials below 4.7 volts were observed: 0.4, 0.8, 1.4, 1.8, 2.3, and 2.7 volts. They are believed to be due to the mercury molecule. The magnitude of such negative ion currents increases more rapidly than the first power of the vapor pressure. Only those formed at about 2.3 and 2.7 volts are measurable at low vapor pressures such as in the paper referred to above. There is evidence that the number of negative ions formed per unit electron current increases more rapidly with increase of vapor pressure for driving potentials of 0.4, 0.8, and 1.4 volts than for those formed at 2.3 and 2.7 volts and all of the atomic critical potentials discussed in the former paper. The negative ions formed at the lower voltages are especially prominent when liquid mercury is present in the tube. It is probable that critical potentials lower than 0.4 volt may be found as the pressure is further increased.

On Some Ultra-Ionization Potentials of Mercury Vapor. ROBERT D. POTTER.

Electrons from a hot filament, collimated by a series of openings, are projected down the axis of a tube containing saturated mercury vapor at 25 degrees. Certain of these electrons ionize atoms and the ratio of the positive ion current to the total current is plotted against the electron driving potential, as this is varied from below the ionization potential at 10.4 volts, up to 14 volts. Previous work by Lawrence and Morris is verified and new potentials are recorded at 11.0–12.4–12.8–13.25 volts. The conclusions of Lawrence as to the probability of ionization at any driving potential are substantiated and from the existing experimental conditions, the theory of Loyarte, as to the nature of these ultra-ionization potentials, appears to be untenable.

CONSTITUTION OF THE NORTH CAROLINA ACADEMY OF SCIENCE

(*Revised to date*)

ARTICLE I

NAME AND OBJECT

Section 1. The name of this organization shall be the "North Carolina Academy of Science."

Section 2. The objects of the Academy shall be to promote study and scientific research and to furnish, so far as practicable, a means of publication of such articles as may be deemed worthy.

ARTICLE II

MEMBERSHIP AND DUES

Section 1. Any person actively interested in science or the promotion of science, may, upon nomination by two members, be elected a Member of the Academy by a majority vote of the Executive Committee, and shall be entitled to all privileges of the Academy.

Section 2. The initiation fee shall be $2.00, payable in advance, and there shall be no annual dues for the first year.

Section 3. The annual dues for old members shall be $2.00, and any person in arrears at the date of the annual meeting forfeits all privileges of the Academy.

Section 4. Any public spirited person donating one hundred dollars or more to the Academy may be elected a Patron of the Academy and shall be entitled to full privileges of membership.

ARTICLE III

OFFICERS

Section 1. The officers of the Academy shall be a President, Vice-President, Secretary-Treasurer, and an Executive Committee of six including the President, Vice-President, and Secretary, of which three shall constitute a quorum. The President and Vice-President shall be

elected for one year. The Secretary-Treasurer, and three members of the Executive Committee for three years, one of these three members to be elected each year. All officials shall be elected, by ballot, by majority vote.

Section 2. The duties of all officers shall be such as usually pertain to such positions. The term of office shall begin with the adjournment of the meeting at which the elections are held and shall expire with the adjournment of the next regular annual meeting.

ARTICLE IV

REPRESENTATIVES

Section 1. The Academy representative to the American Association for the Advancement of Science shall be elected for a two year period.

ARTICLE V

MEETINGS

Section 1. The time and place of all meetings shall be determined by the Executive Committee, but there shall be at least one meeting annually for the presentation and discussion of papers, and at least one business meeting annually.

Section 2. Two weeks notice shall be given of all meetings, and those present at such meetings shall constitute a quorum.

ARTICLE VI

PUBLICATIONS

Section 1. The official organ of the Academy shall be the Journal of the Elisha Mitchell Scientific Society, published at the University of North Carolina. The Editor of the Journal and the Secretary of the Academy shall compose the editorial board for the Academy, subject to the general control of the Executive Committee of the Academy.

ARTICLE VII

AMENDMENTS

Section 1. This constitution may be amended by a two-thirds vote of those present at any regular meeting: Provided, that such amendments be submitted in writing to the Executive Committee at least two weeks before the meeting at which action is to be taken.

BY-LAWS

1. The Executive Committee shall fill all vacancies occurring between meetings of the Academy.

2. Upon the written request of three or more members, the Secretary shall call a meeting of the Executive Committee, to consider such matters as may be laid before it, said meeting to take place within ten days from the time the request is submitted.

3. All elections to membership which take place subsequent to the annual meeting for the presentation of papers, shall apply to the following *calendar year*, and no initiation fee can be collected for the year of such election. All elections to membership, which take place at or before the annual meeting for the presentation of papers, shall apply to the calendar year in which the election takes place, and the initiation fee shall be collected accordingly.

4. The application for membership shall be accompanied by the initiation fee ($2.00), the same to be returned to the applicant should he not be elected.

5. Yearly dues for old members regularly become payable on October 1st of each year.

6. The Secretary-Treasurer, during his term of office, shall not be liable for annual dues, and his necessary expenses in attending the regular meetings shall be defrayed from the treasury of the Academy.

OFFICERS OF THE NORTH CAROLINA ACADEMY OF SCIENCE, 1902–1929

1902

President.....W. L. Poteat
Vice-President.....T. G. Pearson
Secretary-Treasurer.....F. Sherman, Jr.

1903

President.....C. M. Edwards
Vice-President.....C. E. Brewer
Secretary-Treasurer.....F. Sherman, Jr.

1904

President.....Chas. Baskerville
Vice-President.....J. I. Hamaker
Secretary-Treasurer.....F. Sherman, Jr.

1905

President.....F. L. Stevens
Vice-President.....J. F. Lanneau
Secretary-Treasurer.....F. Sherman, Jr.

1906

President.....J. F. Lanneau
Vice-President.....Tait Butler
Secretary-Treasurer.....F. L. Stevens

1907

President.....Collier Cobb
Vice-President.....J. L. Lake
Secretary-Treasurer.....F. L. Stevens

1908

President.....T. G. Pearson
Vice-President.....W. C. Coker
Secretary-Treasurer.....E. W. Gudger

1909

President.....Tait Butler
Vice-Presidemt.....J. J. Wolfe
Secretary-Treasurer.....E. W. Gudger

1910

President.....W. C. COKER
Vice-President.....W. H. PEGRAM
Secretary-Treasurer.....E. W. GUDGER

1911

President.....W. H. PEGRAM
Vice-President.....W. S. RANKIN
Secretary-Treasurer.....E. W. GUDGER

1912

President.....H. V. WILSON
Vice-President.....W. A. WITHERS
Secretary-Treasurer.....E. W. GUDGER

1913

President.....C. S. BRIMLEY
Vice-President.....J. F. LANNEAU
Secretary-Treasurer.....E. W. GUDGER

1914

President.....F. SHERMAN, JR.
Vice-President.....Z. P. METCALF
Secretary-Treasurer.....E. W. GUDGER

1915

President.....J. J. WOLFE
Vice-President.....A. H. PATTERSON
Secretary-Treasurer.....E. W. GUDGER

1916

President.....A. S. WHEELER
Vice-President.....W. A. WITHERS
Secretary-Treasurer.....E. W. GUDGER

1917

President.....F. P. VENABLE
Vice-President.....H. C. BEARDSLEE
Secretary-Treasurer.....E. W. GUDGER

1918

President.....W. A. WITHERS
Vice-President.....J. H. PRATT
Secretary-Treasurer.....E. W. GUDGER

1919

President.....E. W. GUDGER
Vice-President.....H. B. ARBUCKLE
Secretary-Treasurer.....B. CUNNINGHAM

1920

President.....A. H. PATTERSON
Vice-President.....R. N. WILSON
Secretary-Treasurer.....R. W. LEIBY

1921

President.....Z. P. METCALF
Vice-President.....J. M. BELL
Secretary-Treasurer.....R. W. LEIBY / Acting C. S. BRIMLEY

1922

President.....J. L. LAKE
Vice-President.....J. H. PRATT
Secretary-Treasurer.....B. CUNNINGHAM

1923

President.....A. HENDERSON
Vice-President.....H. B. ARBUCKLE
Secretary-Treasurer.....B. CUNNINGHAM

1924

President.....C. M. HECK
Vice-President.....J. P. GIVLER
Secretary-Treasurer.....BERT CUNNINGHAM

1925

President.....H. B. ARBUCKLE
Vice-President.....LULA G. WINSTON
Secretary-Treasurer.....BERT CUNNINGHAM

1926

President.....J. P. GIVLER
Vice-President.....J. O. HALVERSON
Secretary-Treasurer.....BERT CUNNINGHAM

1927

President.....BERT CUNNINGHAM
Vice-President.....F. E. RICE
Secretary-Treasurer.....H. R. TOTTEN

1928

President.....J. M. BELL
Vice-President.....W. L. PORTER
Secretary-Treasurer.....H. R. TOTTEN

1929

President.....J. S. HOLMES
Vice-President.....MISS MARY PETTY
Secretary-Treasurer.....H. R. TOTTEN

MEMBERSHIP ROLL

July 23, 1928

NAME	DEGREES	ADMITTED TO ACADEMY	INSTITUTION ADMITTED FROM	INSTITUTION NOW IN	DEPARTMENT NOW IN	PRESENT RANK
Abernethy, J. R.	M.A.	1927	U.N.C.	U.N.C.	M.	I.
Ader, O. B.	M.A.	1928	D.U.	D.U.	P.	G.S.
Alexander, W. T.	A.B.	1927	U.N.C.	R.C.C.		Insp.
Amick, T. C.	Ph.D.	1923	E.C.	E.C.	M.	P.
Anderson, C. A.	M.D.	1926			Med.	
Anderson, D. B.	Ph.D.	1926	S.	S.	Bo.	Pa.
Arbuckle, H. B.	Ph.D.	1918	D.C.	D.C.	C.	P.
Ashe, W. W.	M.S.	1902*	G.S.	U.S.F. S.	F.	
Avery, G. S., Jr.	Ph.D.	1927		D.U.	Bo.	I.
Bacon, Mabel L.	M.A.	1927	P.I.	U.N.C.	Ps.	G.S.
Bailey, J. L.	M.A.	1927	U.N.C.	U.T.	Med.	I.
Barber, Lena	M.S.	1923	M.	M.	B.	P.
Barkley, Mabel A.		1927	H.S.	H.S.	S.	T.
Barrett, H. P.	M.D.	1920			Med.	
Barrow, Elva	M.S.	1921	N.C.C. W.	N.C.C. W.	C.	P.A.
Beers, C. D.	Ph.D.	1927	U.N.C.	U.N.C.	Z.	Pa.
Bell, Francis M.	M.S.	1928	U.N.C.	U.N.C.	H. & S.	C.E.
Bell, J. M.	Ph.D.	1915	U.N.C.	U.N.C.	C.	P.
Bender, J. A.	M.S.	1928	U.N.C.	U.N.C.	Med.	I.
Binford, Raymond	Ph.D.	1902*	Gu.	Gu.	B.	Pres.
Blomquist, H. L.	Ph.D.	1921	D.U.	D.U.	Bo.	P.
Bomar, Miss Willie M.	M.A.	1927	E.C.T. C.	E.C.T. C.	S.	T.
Boomhour, J. G.	A.M.	1905*	M.	M.	P.	Dean
Bradbury, O. C.	Ph.D.	1926	W.F.	W.F.	B.	P.
Brannon, C. H.	M.S.	1926	S.	S.	Z. & Ent.	En.Ex.
Braudwell, L. J.	A.B.	1928	Teach. H.S.	U.C.	M.	S.
Braxton, H. H.	A.B.	1926	U.N.C.	U.N.C.	B.	A.
Brimley, C. S.		1902c		A.	Ent.	En.a.
Brimley, H. H.		1902c	Mus.	Mus.		D.
Brooks, G. S.	B.S.	1928	D.C. S.	D.C. S.	B.	S. Dean
Brown, B. F.						
Browne, E. T.	Ph.D.	1923*	U.N.C.	U.N.C.	M.	P.A.

* Date of original application, which later lapsed.
c, in date column, charter member.

MEMBERSHIP ROLL—*Continued*

NAME	DEGREES	ADMITTED TO ACADEMY	INSTITUTION ADMITTED FROM	INSTITUTION NOW IN	DEPARTMENT NOW IN	PRESENT RANK
Bruner, S. C.	B.S.	1910	S.	Cuban. Gov't	Ent.	
Bryson, H. J.	M.A.	1923	U.N.C.	C. & D.	M.R.	S.G.
Buck, J. S.	Ph.D.	1926	D.U.	D.U.	C.	Pa.
Bullitt, J. B.	M.A., M.D.	1920	U.N.C.	U.N.C.	Med.	P.
Bullock, R. C.	M.A.	1928	U.N.C.	U.N.C.	M.	I.
Bush, L. E.	S.M.	1926	U.N.C.	U.N.C.	M.	I.
Bynum, J. C.	A.M.	1926	U.N.C.	U.N.C.	G.	Pa.
Cain, Wm.	D.Sc.	1903	U.N.C.	U.N.C.	M.	P.Em.
Cameron, Frank K.	Ph.D.	1928	U.N.C.	U.N.C.	C.	P.
Campbell, Eva G.	M.A.	1921	N.C.C.W.	G.	B.	P.A.
Campbell, Roy J.	C.P.H.	1924	S.C.	S.C.	B.	Pa.
Carrington, G. L.	A.M., M.D.	1927		R.H.	Med.	M.D.
Carroll, R. S.	M.D.	1926	H.H.	H.H.	Psych.	D.
Chapin, Ethel M.	B.S.	1928	A.N.	A.N.	C.	I.
Clifford, A. T.	M.S.	1927	U.N.C.	U.N.C.	C.	A.
Cobb, Collier.	D.Sc.	1902	U.N.C.	U.N.C.	G.	P.
Cobb, W. B.	Ph.D.	1914	U.N.C.	S.	Ag.S.	P.
Coker, R. E.	Ph.D.	1904*	F.B.S.	U.N.C.	Z.	P.
Coker, W. C.	Ph.D.	1902	U.N.C.	U.N.C.	B.	Kenan P.
Colby, C. D.	M.D.	1926	W.L.D.C.	W.L.D.C.	Med.	C.
Collins, G. D.	M.A.	1927	D.U.	D.U.	P.	Pa.
Couch, A. B.		1927	U.N.C.	U.N.C.	B.	A.
Couch, J. N.	Ph.D.	1920	U.N.C.	U.N.C.	B.	Pa.
Crockford, H. D.	Ph.D.	1925	U.N.C.	U.N.C.	C.	P.A.
Cummings, J. L.	A.M.	1927	S.	S.	C.	I.
Cunningham, B.	Ph.D.	1913	H.S.	D.U.	B.	P.
Dashiell, J. F.	Ph.D.	1922	U.N.C.	U.N.C.	Ps.	P.
Davis, Harry T.	M.A.	1919	U.N.C.	Mus.	G.	Da. & Cu.A.
Denson, L. A.		1910*	U.S.W.B.	U.S.W.B.	Sec.	C.
Derieux, J. B.	Ph.D.	1920	S.	S.	P.	P.
Dienes, L.	M.D.	1926	V.R.	V.R.	Med.	D.
Dixon, A. A.	M.A.	1913	Gu.	S.	P.	P.A.
Edminster, F. H.	Ph.D.	1925	U.N.C.	U.N.C.	C.	P.A.
Edwards, C. W.	M.A.	1902	D.U.	D.U.	P.	P.
Eliason, Mary H.	M.A.	1927	M.C.	M.C.	B.	T.

MEMBERSHIP ROLL—*Continued*

NAME	DEGREES	ADMITTED TO ACADEMY	INSTITUTION ADMITTED FROM	INSTITUTION NOW IN	DEPARTMENT NOW IN	PRESENT RANK
Elliott, W. W.	Ph.D.	1926	D.U.	D.U.	M.	P.
Fant, G. W.	M.S.	1923	S.	S.	P.D.	P.P.Ex.
Fisher, H. A.	Grad.	1928	S.	S.	M.	Pa.
Frothingham, E. H.	M.S.	1922	U.S.F.S.	U.S.F.S.	Ap.F.S.	D.
Fulcher, H. E.	M.S.	1926	D.C.	D.C.	P.	P.
George, W. C.	Ph.D.	1913*	U.N.C.	U.N.C.	Med.	P.
Ginnings, P. M.	Ph.D.	1927	G.C.	G.C.	C. & P.	P.
Givler, J. P.	A.M.	1921	N.C.C.W.	N.C.C.W.	B.	P.
Glenn, Mrs. Jane C.	M.S.	1927	F.M.C.	F.M.C.	C.	P.
Goldston, E. F.		1928	S.	S.	G.	S.
Graham, Maria D.	M.A.	1928	E.C.T.C.	E.C.T.C.	M.	T.
Gray, Cora E.	Ph.D.	1928	Cat.	Cat.	H.E.	P.
Gudger, E. W.	Ph.D.	1906	N.C.C.W.	A.M.	I.	B. & A.
Hall, Earl H.	M.S.	1924	N.C.C.W.	N.C.C.W.	B.	P.
Hall, F. G.	Ph.D.	1927	D.U.	D.U.	Z.	P.A.
Halverson, J. O.	Ph.D.	1920	A.	S.	Exp.	
Hammond, W. C., Jr.	B.S.	1927	U.N.C.	F. & R.	C.	C.
Hatley, C. C.	Ph.D.	1919*	D.U.	D.U.	P.	Pa.
Heck, C. M.	M.A.	1920	S.	S.	P.	P.
Henderson, Archibald.	Ph.D.	1904*	U.N.C.	U.N.C.	M.	P.
Hildebrand, S. F.	Ph.D.	1926	F.B.S.	F.B.S.	Beau.	D.
Hill, L. L.	M.A.	1925	U.N.C.	U.N.C.	Z.	A.
Hill, M. A.	M.A.	1923	U.N.C.	U.N.C.	M.	Pa.
Hirsch, N. D. M.	Ph.D.	1928	D.U.	D.U.	Ps. & Phil.	I.
Hobbs, A. W.	Ph.D.	1910	Gu.	U.N.C.	M.	P.
Holl, F. J.	Ph.D.	1927	D.U.	U.B.	Z.	I.
Holland, Alma	A.B.	1920	U.N.C.	U.N.C.	Bo.	A.
Holmes, J. S.	M.F.	1902	G.S.	C. & D.	F.	S.F.
Hook, A. L.	M.A. & M.S.	1922	E.C.	E.C.	P.	P.
Hopkins, D. L.	Ph.D.	1927	D.U.	D.U.	Z.	I.
Hostetler, E. H.	M.S.	1924	S.	S.	Ag.	P.
Hursh, C. R.	Ph.D.	1927	U.S.F.S.	U.S.F.S.	Ap.F.S.	F.E.A.
Ingraham, Helen	M.A.	1928	N.C.C.W.	N.C.C.W.	B.	Pa.
Ives, J. D.	M.A.	1910	W.F.	C.N.	B.	P.

MEMBERSHIP ROLL—*Continued*

NAME	DEGREES	ADMITTED TO ACADEMY	INSTITUTION ADMITTED FROM	INSTITUTION NOW IN	DEPARTMENT NOW IN	PRESENT RANK
Jones, E. P.	M.A.	1921*	D.U.	D.U.	C.	
Jordan, W. E.	M.S.	1922*	S.	S.	C.	Pa.
Kilgore, B. W.	Sc.D.	1902*	A.	A.C.G.E.	Tr.	Ch.
Kirkpatrick, D. E.		1928c	D.U.	D.U.		S.
Klemm, Ethel M.	A.B.	1928	A.N.	A.N.	B.	I.
Korstian, C. F.	Ph.D.	1922	U.S.F.S.	U.S.F.S.	Ap.F.S.	Siv.
Kyser, E. V.	Ph.C.	1927	U.N.C.	U.N.C.	Phar.	P.A.
Lake, J. L.	A.M.	1902*	W.F.	W.F.	P.	P.
Lalor, Marjorie J.	A.B.	1925	P.I.	P.I.	B.	P.
Laubenfels, M. W.	A.M.	1928	C.I.	C.I.	Z.	
Lasley, J. W., Jr.	Ph.D.	1921	U.N.C.	U.N.C.	M.	P.
Lawson, A. B.	M.D.	1928	U.N.C.	U.N.C.	Med.	P.D.
Lay, George W.	D.C.L.	1910*	S.M.S.			Rect.
Ledbetter, Ida Belle	M.A.	1928	Ap.S.N.	Ap.S.N.	B.	P.
Lee, F. A., Jr.	M.A.	1926	S.	S.	M.	I.
Lee, Mrs. Selma	M.A.	1928	U.N.C.	U.N.C.	Z.	A.
Lehman, S. G.	Ph.D.	1920	S.	S.	Bo.	P.
Leiby, R. W.	Ph.D.	1915	A.	A.	Ent.	S.En.
Lineberry, Margaret	M.A.	1928	W.F.		B.	S.
Lineberry, R. H.	M.S.	1925	U.N.C.	M.H.C.	C.	P.
Ljung, H. A.	M.S.	1927	U.N.C.	U.N.C.	C.	A.
Love, James Lee	M.A.	1928				P.ret.
Lyon, S. C.	D.Sc.	1927	D.C.	D.C.	B.	P.
MacCarthy, Gerald R.	Ph.D.	1923	U.N.C.	U.N.C.	G.	Pa.
MacNider, W. de B.	M.D.	1911*	U.N.C.	U.N.C.	Med.	Kenan P.
McCrea, T. R.	B.S.	1928	S.B.H.	S.B.H.	S.E.	S.Ea.
McDougall, Wm.	D.Sc.	1927	D.U.	D.U.	P.S.	P.
McPhaul, A. H.	B.S.	1928	D.C.	D.C.	B.	S.
Mackie, E. L.	Ph.D.	1923	U.N.C.	U.N.C.	M.	P.A.
Mangum, C. S.	M.D.	1902*	U.N.C.	U.N.C.	Med.	P.
Manning, I. H.	M.D.	1902*	U.N.C.	U.N.C.	Med.	P.
Martin, Ella M.	Ph.D.	1927	G.C.	G.C.	B.	P.
Mathews, A. C.	A.B.	1928	U.N.C.	H.S.	S.	T.
Matthews, Velma	M.A.	1926	U.N.C.	U.N.C.	Bo.	A.
Meacham, F. B.	M.S.	1924	S.	S.	Z. & En.	Pa.
Meares, J. S.	M.S.	1924	S.	S.	P.	Pa.
Mebane, W. N., Jr.	B.S.	1927	D.C.	D.C.	M.	Pa.
Meserve, C. F.	LL.D.	1923	Shaw			Pres. Em.

MEMBERSHIP ROLL—*Continued*

NAME	DEGREES	ADMITTED TO ACADEMY	INSTITUTION ADMITTED FROM	INSTITUTION NOW IN	DEPARTMENT NOW IN	PRESENT RANK
Metcalf, Z. P.	D.Sc.	1909	A.	S.	Z. & En.	P.
Miller, H. K., Jr.	Ph.D.	1927	D.U.	D.U.	C.	Pa.
Mills, R. C.		1927	H.G.	H.G.	Eng.	Eng.
Mitchell, T. B.	D.Sc.	1921	A.	S.	Z. & En.	Pa.
Mourane, J. H.	M.S.	1926	H.P.C.	H.P.C.	C.	P.
Murray, V. F.	M.A.	1927	Cat.	Cat.	M. & P.	P.
Nowell, J. W.	Ph.D.	1915	W.F.C.	W.F.C.	C.	P.
Ott, C. N.	Ph.D.	1927	G.	G.	C.	P.
Patterson, A. H.	D.Sc.	1910	U.N.C.	U.N.C.	P.	Dean
Patterson, P. M.	M.A.	1925	D.C.	D.C.	B.	I.
Pearse, A. S.	Ph.D.	1927	D.U.	D.U.	Z.	P.
Pegram, Annie M.	M.A.	1923	G.C.	G.C.	M.	P.
Penney, J. T.	M.A.	1925	U.N.C.	U.N.C.	Z.	A.
Perry, J. W.		1928	S.	S.	P.	G.S.
Petty, Mary	B.S.	1910*	N.C.C.W.	N.C.C.W.	C.	P.
Pickens, R. H.		1926				
Pleasants, Annie Lewis.	M.A.	1928	N.C.C.W.	N.C.C.W.	B.	I.
Plyler, E. K.	Ph.D.	1925	U.N.C.	U.N.C.	P.	P.A.
Poole, R. F.	Ph.D.	1926	S.	S.	Bo.	P.A.
Porter, W. L.	M.A.	1922	D.C.	D.C.	B.	P.
Poteat, W. L.	M.A., LL.D.	1902c*	W.F.	W.F.	B.	P.
Potter, R. D.	B.S.	1928	D.U.	U.B.	P.	
Powell, T. E., Jr.	M.A.	1921	E.C.	E.C.	B.	P.
Preston, C. E.	Ph.D.	1927	U.N.C.	U.N.C.	Educ.	P.A.
Prouty, W. F.	Ph.D.	1920	U.N.C.	U.N.C.	G.	P.
Puckett, W. O.	A.B.	1927	D.C.	D.C.	B.	I.
Purdom, E. G.	M.S.	1928	Gu.	Gu.	P.	P.A.
Ragsdale, Virginia	Ph.D.	1913*	N.C.C.W.	N.C.C.W.	M.	P.
Ramsey, G. G.	Ph.D.	1926	Cat.	Cat.	C.	P.
Randolph, E. E.	Ph.D.	1916	E.C.	S.	C.	P.
Randolph, E. O.	D.Litt.	1914	U.N.C.		G.	
Rankin, W. W.	M.A.	1927	D.U.	D.U.	M.	P.
Reid, James	B.S.	1927	D.C.	U.C.	B.	G.S.
Reinholt, O. R.	B.S.	1928				O.S.
Rhodes, G. W.	A.B.	1926	H.S.	H.S.	S.	Prin. & I.
Rhodes, L. B.	M.S.	1919	A.	A.	F. & O.	Chem. A.
Robert, Nan L.	M.S.	1925	F.M.C.	F.M.C.	B.	P.
Robinson, Mrs. W. F.	A.M.	1927	M.H.C.	M.H.C.	M.	P.

MEMBERSHIP ROLL—*Continued*

NAME	DEGREES	ADMITTED TO ACADEMY	INSTITUTION ADMITTED FROM	INSTITUTION NOW IN	DEPARTMENT NOW IN	PRESENT RANK
Rodgers, S. E., Jr.	M.A.	1924	S.	S.	P.	I.
Rogers, J. S.	M.S.	1928			C.	Chem.
Roller, A. F.	M.S.	1921	H.S.	E.T.S.T.	S.	I.
Roseberry, H. H.	M.A.	1928	D.C.	D.C.	P.	I.
Ruffner, R. H.	B.S.	1921	S.	S.	A.H. & D.	C.
Rumbold, Dean W.	B.S.	1927	D.U.	D.U.	Z.	A.
Russell, G. A.	Ph.G., B.S.	1927	V.C.	V.C.	C.	Chem.
Satterfield, G. H.	A.M.	1920*	D.U.	S.	C.	Pa.
Saville, Thorndike	M.S.	1919	U.N.C.	U.N.C.	H. & S.	P.
Seeley, W. J.	M.S.	1927	D.U.	D.U.	E.E.	P.A.
Seymour, Mary F.		1917*	N.C.C.W.	Cat.	B.	P.
Shaftesbury, A. D.		1927	N.C.C.W.	N.C.C.W.	B.	P.A.
Sharpe, Lucile	A.B.	1928	N.C.C.W.	N.C.C.W.	B.	S.
Shelton, G. R.	Ph.D.	1926	S.	S.	C.	P.A.
Sherman, Franklin	M.S.	1902c	A.	Clem.	Z. & En.	C.
Sherrill, Mary L.	Ph.D.	1919	N.C.C.W.	Mt.H.C.(1)	C.	
Sherwood, F. W.	Ph.D.	1910*	Exp.	Exp.	N.	A.
Shore, C. A.	M.D.	1909*	S.P.H.	S.P.H.	S.L.H.	D.
Shunk, I. V.	A.M.	1920	S.	S.	Bo.	Pa.
Slater, Florence W.	B.S.	1928			B.	L.
Smith, A. R.	A.M.	1928	Ap.S.N.	Ap.S.N.	C.	P.
Smiley, T. B.	B.S.	1928	U.N.C.	U.N.C.	E.E.	I.
Snyder, Lawrence H.	M.S.	1924*	S.	S.	Z.	P.
Speas, W. E.	Ph.D.	1921	W.F.	W.F.	P.	P.
Stanfield, Wesley		1928	D.U.	D.U.	Z.	S.
Stiles, C. W.	M.D., Ph.D., D.S.C.	1910*	R.S.C.	U.S.P.H.	Z.	P.
Strong, Cora	A.B.	1910*	N.C.C.W.	N.C.C.W.	M.	P.
Stuckey, J. L.	Ph.D.	1926	U.N.C.	S.	G.	P.
Stuhlman, Otto, Jr.	Ph.D.	1921*	U.N.C.	U.N.C.	P.	P.
Swartz, J. H.	Ph.D.	1925	U.N.C.	U.N.C.	G.	P.A.
Taylor, C. C.	Ph.D.	1921	S.	S.	A. & Soc.	Dean
Terrill, Elizabeth D.	A.M.	1927	S.M.S.	S.M.S.	C.	P.
Thies, O. J., Jr.	M.A.	1921	D.C.	D.C.	C.	P.A.

(1) On leave, 1928–29 C.R.B. Fellow at the University of Brussels. Research in Ethylenic Isomerism.

MEMBERSHIP ROLL—*Concluded*

NAME	DEGREES	ADMITTED TO ACADEMY	INSTITUTION ADMITTED FROM	INSTITUTION NOW IN	DEPARTMENT NOW IN	PRESENT RANK
Thomas, C. L.	B.S.	1927	U.N.C.	U.N.C.	C.	A.
Thompson, H. T.	M.A.	1926	U.N.C.	U.N.C.	G.	A.
Totten, H. R.	Ph.D.	1914	U.N.C.	U.N.C.	Bo.	P.A.
Traver, J. R.	M.A.	1928	N.C.C.W.	N.C.C.W.	B.	I.
Trawick, M. W.	A.B.	1927	U.N.C.	U.N.C.	P.	I.
Trentham, S. O.	A.B.	1926	M.H.	M.H.	B.	P.
Venable, F. P.	Ph.D., D.Sc.	1902	U.N.C.	U.N.C.	C.	P.
Vilbrandt, F. C.	Ph.D.	1922	U.N.C.	U.N.C.	C.	P.
Vollmar, Dominic	A.B.	1925	B.A.	B.A.	C.	P.
Warren, R. M.	M.S.	1927	H.S.	H.S.	S.	T.
Wells, B. W.	Ph.D.	1920	S.	S.	Bo.	P.
Wells, Mrs. B. W.		1921	H.S.	H.S.	B.	T.
Wentz, Bruce A.	Ph.D.	1928	Cat.	Cat.	Psy.	P.
Wheeler, A. S.	Ph.D.	1903	U.N.C.	U.N.C.	C.	P.
Whitehurst, H.		1926	H.S.	H.S.		Prin.
Whitford, L. A.	B.S.	1928	S.	S.	Bo.	I.
Whiting, Mrs. P. W.	Ph.D.	1928	Cat.	Cat.	B.	P.A.
Whitley, Ona Ruth	A.B.	1927	H.S.	H.S.	B.	T.
Williams, C. B.	M.S.	1902*	A.	S.	A.	P.
Williams, L. F.	Ph.D.	1910	S.	S.	C.	P.
Williams, Maude	M.A.	1928	N.C.C.W.	N.C.C.W.	Ps.	I.
Willis, L. G.	M. S.	1924	S.	S.	Ag.	P.
Willoughby, J. E.	C.E.	1926	A.C.L.	A.C.L.	Eng.	C.
Wilson, H. V.	Ph.D.	1902	U.N.C.	U.N.C.	Z.	Kenan P.
Wilson, R. N.	M.S.	1902	Gu.	D.U.	C.	P.
Winsor, Arthur S.	Ph.D.	1923*	U.N.C.	U.N.C.	M.	P.A.
Winston, Lula G.	Ph.D.	1921	M.	M.	C.	P.
Wolf, F. A.	Ph.D.	1915	S.	D.U.	B.	P.
Wolff, W. A.	A.B.	1923				
Womack, A. W.	A.B.	1923	U.N.C.		P. & S.	Sup.
Wrenn, S. N.	A.B.	1927	D.U.	D.U.	C.	A.
Wright, E. Katherine	M.A.	1921	N.C.C.W.	N.C.C.W.	C.	P.A.
Wright, W. T.	M.S.	1922*	N.C.C.W.	N.C.C.W.	P.	P.
Wyatt, W. J.	M.A.	1926	W.F.	W.F.	C.	Pa.
Yocum, L. E.	Ph.D.	1922*	N.C.C.W.	N.C.C.W.	B.	P.A.
Yoder, M. C.		1927	L.R.	L.R.	B.	P.
Zoeller, Edward V.	P.D., Ph.G.	1923	Phar.B.	Phar.B.		Pres.

Code under Institution

A., N. C. Department of Agriculture
A.C.G.E., American Cotton Growers Exchange
A.C.L., Atlantic Coast Line Rail Road
A.M.N.H., American Museum of Natural History
A.N., Asheville Normal
Ap.S.N., Appalachian State Normal, Boone
B.A., Belmont Abbey College
Cat., Catawba College
C. & D., N. C. Department of Conservation and Development
C.I.N., Cherokee Indian Normal School
Clem., Clemson College
C.N., Carson and Newman College
Col., Columbia University
D.C., Davidson College
D.U., Duke University
E.C., Elon College
E.C.T.C., East Carolina Training College
E.T.S.T., East Tennessee State Teachers College
Exp., State Experiment Station
F.B.S., U. S. Fisheries Biological Station
F.M.C., Flora McDonald College
F. & R., Froehling and Robertson, Inc.
G.C., Greensboro College
G.S., N. C. Geological Survey
Gu., Guilford College
H.G., Harris Granite Company, Salisbury
H.H., Highland Hospital
H.P.C., High Point College
H.S., High School
L.R., Lenoir Rhyne College
M., Meredith College
M.C., Mitchell College
M.H.C., Mars Hill College
Mt.H.C., Mount Holyoke College
Mus., State Museum
N.C.C.W., North Carolina College for Women
Phar., North Carolina Board of Pharmacy
P.I., Peace Institute
R.C.C., Retail Credit Company, Charlotte
R.H., Rainey Hospital, Burlington
R.S.C., Rockefeller Sanitary Commission
S., State College
S.C., Salem College
S.M.S., St. Mary's School
S.P.H., State Department of Public Health
U.B., University of Buffalo

U.C., University of Chicago
U.N.C., University of North Carolina
U.S.F.S., United States Forest Service
U.S.P.H., United States Public Health Service
U. S. W. B., United States Weather Bureau
U.T., University of Tennessee
V.C., Vick Chemical Company, Greensboro
V.R., Von Ruck Laboratory, Asheville
W.F., Wake Forest College
W.L.D.C., The William LeRoy Dunn Clinic, Asheville

Code under Department

A., Agriculture
Ag., Agronomy
Ag.S., Agronomy, soils
A.H., Animal Husbandry
B., Biology
Beau., Beauford Station
Bo., Botany
C., Chemistry
C. & P., Chemistry and Physics
Educ., Education
E.E., Electrical Engineering
Eng., Engineering
Ent., Entomology
Exp., Experiment Station
F., Forestry
G., Geology
F. & O., Food and Oil
H.E., Home Economics
H. & S., Hydraulic and Sanitary Engineering
I., Ichthyology
M., Mathematics
Med., Medical
M. & P., Mathematics and Physics
M.R., Mineral Resources
N., Nutrition
P., Physics
Phar., Pharmacy
Phar.B., N. C. Pharmacy Board
P.D., Plant Diseases
Phil., Philosophy
Ps., Psychology
P. & S., Parks and School Grounds
Psych., Psychiatry
R., Research
S., Science

S.E., Sanitary Engineering
Sec., N. C. Section
S.L.H., State Laboratory of Hygiene
Soc., Sociology
T., Teacher
Tr., Trustee
Z., Zoology

Code under Rank

A., Assistant
B. & A., Bibliographer and Associate
C., Chief
C.E., Civil Engineer
Ch., Chairman
Chem., Chemist
Chem. A., Associate Chemist
Cu.A., Associate Curator
D., Director
Da., Assistant Director
Eng., Engineer
En.A., Assistant Entomologist
En.Ex., Extension Entomologist
F.E.A., Associate Forest Ecologist
G.S., Graduate Student
I., Instructor
Insp., Inspector
L., Lecturer
M.D., Physician
O.S., Oil Specialist
P., Professor
P.A., Associate Professor
Pa., Assistant Professor
P.Em., Professor Emeritus
P.Ret., Retired Professor
Pres., President
Pres. Em., President Emeritus
Prin., Principal
P.D., Physical Director
P.P.Ex., Extension Plant Pathologist
Rect., Rector
S., Student
S.Ea., Assistant Sanitary Engineer
S.En., State Entomologist
S.F., State Forester
S.G., State Geologist
Siv., Siviculturist
Sup., Superintendent
T., Teacher
Tr., Trustee

PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY FOR THE YEAR 1927–1928

298TH MEETING, OCTOBER 11, 1927

W. C. COKER. *The Limits of Life.* (Illustrated.)

Slides were shown illustrating the limits of achievements of animals and plants in various directions,—for example, the oldest and largest trees, the largest animals living and extinct, the longest-lived living animals, the smallest living creatures, the extremes in resistance to heat and cold in active and dormant stages. The difference in the manner of growth of plants and animals was brought out, emphasis being put on the fact that many of the smaller creeping or running plants might be much older than the oldest living trees but that the parts that are at present alive are not older. Slides were shown to illustrate the remarkable mechanism shown in the simple fungus *Pilobolus* and its sensitive response to light leading to the projection of its sporangium in the direction of the light.

299TH MEETING, NOVEMBER 8, 1927

E. T. BROWNE. *Note on the Characteristic Equation of a Matrix.*

This paper is concerned with the characteristic equation of an algebraic matrix A of n rows and n columns, the elements of the matrix being any numbers whatever, real or complex. If the matrix A is of some particular type, certain definite statements can be made concerning the characteristic equation. Thus, for example, if A is a *real symmetric* matrix the roots of the characteristic equation are all *real.* Similarly, if A is a *real orthogonal* matrix the roots of the characteristic equation all have *unit modulus.* These facts are well known. However, if A is not a matrix of some special type, nothing definite was known as to the nature of the roots of its characteristic equation until 1900 when Bendixson, Hirsch and Bromwich gave criteria for the upper limits to the real and the imaginary parts of the roots in terms of the roots of the characteristic equations of the auxiliary matrices $\frac{1}{2}(A+\bar{A}')$, $\frac{1}{2}(A-\bar{A}')$. Here $\bar{A}'$ is the *conjugate* of the *transpose* of A.

In this paper a new criterion is given for an upper limit to the modulus of a characteristic root of A. We introduce the auxiliary matrix $A\bar{A}'$.

We show that the characteristic equation of this matrix is identical with that of the matrix $\bar{A}'A$, and that the roots of this equation are always real and never negative. If R and r denote, respectively, the largest and the smallest of the roots of this equation, then the modulus of a characteristic root of A is never less than r and never exceeds R.

Geometrically, Bendixson's theorem states that the characteristic roots of A lie within a certain rectangle in the complex plane. The criterion given in this paper states that these roots lie within a certain annular region, in fact, a region included between two concentric circles with centre at the origin. In some cases Bendixson's criterion gives the more restricted limits, while in other cases, notably when A is a real orthogonal matrix, the criterion established in this paper gives better limits.

This paper is to appear in full in an early issue of the *Bulletin of The American Mathematical Society.* It has not been presented before any other scientific society.

COLLIER COBB. *Some American Pioneers in Soil Investigation.*

Gerard Troost (1776–1850). Born at Bois-le-Duc, Holland. Travelled widely in France, Italy, Switzerland, and Germany, under commission from the King of the Netherlands. Made large and valuable mineral collection. While working on his geological map of the environs of Philadelphia he made a soil survey of the region.

Eugene W. Hilgard (1883–1916). Born in Rhenish Bavaria. Our earliest direct investigator of soils in connection with their vegetation, and of the influence of climate upon the formation of soils; also one of our students of "alkali lands."

Joseph Buckner Killibrew (1831–1906). Bred plants, wheat, 1871, to suit certain exhausted soils in Tennessee, increasing enormously the yield per acre.

Milton Whitney (1860–1927). Was the first to stress the importance of the physical analysis of soils, so early as 1886, including size of soil-grains, structure and texture of soils. His investigations really mark the formal beginning of a "science of soils," and his work has always been highly esteemed in Europe.

Collier Cobb (1862–). Was the first to point out the value of the mineral analysis of soils and to make such analyses of dune sands and soils (1886) by means of the microscope and the Harada tube.

Frank K. Cameron (1869–). Was the first to realize the importance of the soil solution and an understanding of the phenomena

affecting the composition and movement of the soil moisture. He brought to bear upon this problem the most highly finished technique of the physicist, the chemist, and the bio-chemist (1910).

300TH MEETING, DECEMBER 13, 1927

C. D. BEERS. *The Relation of Diet to Vitality in One-celled Animals.*

The effect of the nature of the food on various life-processes in *Didinium* was examined as follows: A set of pure lines was cultured on paramecia which were in a state of pronounced inanition induced by a week of starvation in spring water. A second set was cultured on well-fed paramecia of maximum size. No limitation was placed on the quantity of food received by the lines of either set.

The lines fed on starved paramecia showed a gradual decrease in fission-rate and an increase in death-rate. These lines died out after thirty-one days of culture. In this time they produced an average of only 36.6 generations per line. The encystment-rate was relatively high during the first week of culture. Seemingly the animals gradually lost the ability to encyst, and the encystment-rate was less than 3 per cent in the last week. Monstrous, distorted, and miniature individuals were numerous among these lines.

The fission-rate of the well-fed lines was constant throughout the period, in which they produced 108.5 generations. Their encystment-rate and death-rate were practically zero, and no abnormalities developed among the lines.

Repetitions of this experiment gave concordant results.

The decline and death of the first set is attributed to dietary deficiencies, since starved paramecia lack the reserve of food substances present in well-fed ones. The experiment affords an instance of inducing degeneration and death in an infusorian as a result of dietary changes. The symptoms of degeneration were similar to those observed by Maupas (1888) in certain ciliata, but attributed by him to senescence and not to environmental factors. The experiments suggest that Maupas was actually dealing with degeneration induced by his cultural methods and not with intrinsic ageing.

THORNDIKE SAVILLE. *Water Supply Investigations in Venezuela.* (Illustrated.)

Following a general presentation of water supply conditions in Venezuela, Mr. Saville proceeded by means of lantern slides to illustrate in some detail his studies made on behalf of the Government of Vene-

zuela for additional water supply for the City of Caracas. It was shown that rainfall amounted only to about 32 inches in the average year, and often dropped as low as 21 inches. During recent droughts the city has been seriously handicapped by lack of water. Elaborate studies of rainfall and stream flow were made, and so far as known constitute the first of this kind ever carried on in Venezuela. The seasonal character of the rainfall was shown to be due to the variation in the intensity of the trade winds due to movement of the heat equator north and south of Caracas. Probability studies of rainfall were presented, and also studies of dry season rainfall. Investigations of stream flow were carried on together with study to determine the effect of storage in meeting water supply necessities.

301ST MEETING, JANUARY 17, 1928

J. W. LASLEY. *A Note on the Cubic with a Cusp.*

The projective differential geometry of plane curves associates with every curve an ordinary linear homogenous differential equation of the third order. The Lagrange adjoint of the latter is satisfied by the line coordinates of the curve. The parametric point equations furnish integrating factors for this adjoint. In this paper the above computations are made for the cubic with a cusp. The integrations involved are performed and the general solution of the adjoint obtained. There is, however, much latitude involved in the choice both of dependent and of independent variables, and this choice materially affects both the differential equation of the given curve and its adjoint. Moreover, one must be careful that the fundamental system of solutions finally obtained leads to the original curve in lines, and not merely to some projectively equivalent curve. A method for doing this is outlined, and the well-known line equation of the cuspidal cubic results.

J. N. COUCH. *The Structure and Development of Some Tropical Fungi Parasitic on Trees.* (Illustrated.)

302ND MEETING, FEBRUARY 14, 1928

E. V. KYSER. *The Flowers and Flower Oils.* (Illustrated.)

An illustrated discussion of the flowers which yield volatile oils, principally those which are cultivated for the purpose in the Grasse section of France. The methods of cultivation, harvesting, and obtaining the oils were given. Details were presented concerning the

use of the processes of distillation, hot and cold maceration, extraction and expression, and the types of flowers adaptable to each process. The chemical composition of a number of the oils was discussed and also the part which synthetic chemicals play in the creation of artificial flower odors.

G. R. MACCARTHY. *Experimental Work on Some of the Processes Involved in the building of Mountains.* (Illustrated.)

303RD MEETING, MARCH 13, 1928

A. H. PATTERSON. *The Packing-Fraction in Atomic Nuclei.*

W. DEB. MACNIDER. *The Occurrence of Atypical Glomeruli in the Kidney of the O'possum.* (Illustrated.)

304TH MEETING, APRIL 10, 1928

W. F. PROUTY. *The Newark Sediments of the Durham Basin.*

ARCHIBALD HENDERSON. *The Spherical and Cylindrical Worlds of Einstein.*

305TH MEETING, MAY 8, 1928

GEORGE HEINITSH. *The Location of Foreign Bodies by Means of X-rays.*

T. F. HICKERSON. *Fundamental Units of Force.*

The nominating committee submitted the following list of nominees for officers of the Elisha Mitchell Scientific Society for the year 1928–1929.

President: J. F. Dashiell.
Vice-President: J. N. Couch.
Permanent Secretary: J. M. Bell.
Recording Secretary and Treasurer: G. R. MacCarthy.
Publications Committee: W. C. Coker, Chairman, A. S. Wheeler, W. F. Prouty.

All nominees were elected.

SOME APPROACHES TO FUNDAMENTAL THEORY OF THE PHYSICAL SCIENCES[1]

By J. M. Bell

It has become the custom of this Academy to hear a statement read by the person whom the Academy has honored by election to its Presidency. These annual addresses are frequently retrospective and occasionally introspective. They pertain to some general topic in which the President is especially interested. On this occasion I desire you to view with me the physical scientist as he approaches the problem which he attempts to solve or elucidate.

If the physical scientist belongs to the school of energeticists, he will measure certain of the external characteristics of the material which is to be studied. He will find the mass, the volume, the pressure, the temperature and perhaps some other data. It was such an investigation which Boyle made when he discovered the famous law of gases which goes by his name and which every freshmen approaching an examination in elementary physics or chemistry should carefully review. It was such an investigation which Charles and Gay-Lussac made when they determined the behavior of gases under changing temperature conditions. Numerous other examples of this sort of investigation could be cited, but time does not permit a multiplication of cases. In such work as I have referred to, no hypothesis or theory is proposed to account for these behaviors. No mechanism is imagined which would offer a mental picture of the inside workings of the material. This point of attack is limited to observable phenomena, and only quantities which are determinable by direct experiment are dealt with. Under the leadership of Ostwald this school has been active in its prosecution of research and has been fruitful of many and varied results. Among the students of Ostwald none is as famous as Nernst, who has written the classical book on theoretical chemistry. It is interesting to note that Nernst does not adhere exclusively to the phenomenological method, for on the title page of this standard book he states that he will take

[1] Presidential Address before the North Carolina Academy of Science, April 27, 1928.

as his guiding principles the laws of thermodynamics which are the foundation stones of this school, and also he assumes the validity of the principle of Avogadro, which you will at once recognize as a fundamental of the school which postulates the existence of atoms and of molecules. Does not the principle of Avogadro state that equal volumes of gases under like conditions of temperature and pressure contain equal numbers of *molecules?* So that even the devotees of observable phenomena cannot refrain from going farther than the observations to ask the questions: How did the material get that way? and How is the thing constituted? The other school is that of the mechanists, and to this class the great majority of chemists belong. Every chemical equation is constructed to represent some reaction, and the reaction is interpreted in terms of the atomic and molecular theories. Much of organic chemistry consists of shrewd detective work to discover into what part of a cluster of atoms a certain other atom or group of atoms injects itself. The working out of mechanisms is a large territory in which many scientists have staked their claims. Such studies of the clusters of atoms, of the ability of atoms to combine with one another, of the possible regroupings of atom clusters comprised at one time the overwhelming mass of productive chemical research, and perhaps this still constitutes the major part of the published investigations. Having divided ourselves into these two classes, devoted to the study of energy or of mechanics it is interesting to view the triumphs which each group has had, and also to observe the difficulties in which each group has found itself.

The subject of energetics, frequently known by the less inclusive name of thermodynamics begins with two simple statements, so fundamental as to defy proof. These generalizations go by the names: the first and second laws of thermodynamics. I fear that the term thermodynamics is heard with misgiving and probably with suspicion. Many of us lose interest when that awful word is used. A recent book by Lewis and Randall, themselves ardent believers in the methods of energetics, contains this statement: "The widespread prejudice against any practical use of thermodynamics in chemistry is not without reason, for the propagandists of modern physical chemistry have at times shown more zeal than scientific caution. We have seen cyclical processes limping about eccentric and not quite completed cycles, we have seen the exact laws of thermodynamics uncritically joined to assumptions comprising half-truths or no truth at all, and worst of all we have seen ill-begotten equations supported by bad data."

Incidentally it may be interesting to observe here that this text of Lewis and Randall has just been read by an advanced class which came to the conclusion that the strictures which I have just quoted might very well apply to the text itself. However that may be, the fact remains that the best friends of the subject of energetics have frequently been its worst enemies.

Let me now recall to you the fundamental laws of thermodynamics. The first is the principle of the conservation of energy, familiar to everyone. Not quite to everyone, for there are still persons who invest in projects involving perpetual motion or perpetual energy obtained without the expenditure of some other form of energy. The second law states that the quantity of energy available for *work* is diminishing, and that the less available form of energy (*heat*) is continually increasing. In other words, *the universe is running down*. This last statement was made quantitative by Carnot about 100 years ago in his famous equation employed by every engineer, engaged in the production of work from heat. These two statements come out of our experience, and like the statement of geometry that a straight line is the shortest distance between two points, they cannot be logically proved. Regarding the employment of these laws, MacDougall says: "Thermodynamics is an empirical science, i.e. it is based on generalizations from experience which find their expression in the First and Second Laws. Hypothetical views as to the constitution of matter or the nature of heat are not used in the development of thermodynamical principles and hence these principles are as certain as the experimental facts on which they are based." This is the classical method of thermodynamics. But there is another opinion or treatment of these laws, stated succinctly by Hinshelwood in his recent book, "I am out of sympathy with those who regard thermodynamics as a science based upon empirical laws independent of the actual nature of things. If it were not for the molecular-kinetic nature of things, there is no particular reason for believing that the laws of thermodynamics would be what they are." So that there are those who take the laws of thermodynamics as the starting point, and there are those who consider that the laws of thermodynamics exist because matter is constituted in a particular way.

Pure thermodynamics, which makes no assumptions regarding the structure of matter, has had some remarkable triumphs, only a few of which I shall take time to mention:

(1) In the realm of engineering, we are definitely informed regarding the maximum quantity of work which can be obtained from a heat

engine, working between given temperatures, and provided with a certain amount of heat at the higher temperature. Actually, inefficiency of operation and design causes a much smaller yield of mechanical energy. From the simple non-condensing engines of Watt, one of which I saw in operation last summer in the South Kensington Museum in London, England, to the very latest improvement in design, constant improvements have been made with the object of more nearly approaching in yield the maximum which is given by the Carnot equation. Thermodynamics tells us how efficient our engines are, but makes no direct suggestion regarding design or materials which are suitable in the operation of the heat transfers.

Another application in the realm of engineering is the modern refrigerator. Just as an equalization of temperatures can be made to produce work in the heat engine, so also work or mechanical energy can be utilized to cause greater inequalities of temperatures between two heat reservoirs. The equation of Carnot tells us how much work (in the form of kilowatt-hours, the unit mentioned on our electric bills) must be employed to lift heat at a low temperature into heat at a higher temperature. The continual removal of heat from the refrigerator compensates for the heat which leaks into the refrigerator through the walls.

The equation of Carnot allows us to make another calculation, which is striking and suggestive. It suggests the possibility of heating buildings by obtaining heat from the outside world at low temperature and boosting the temperature to that desired inside the building. This calculation shows that working between 32°F. and 68°F. the amount of electric energy necessary to run a motor to do the necessary work would be only $\frac{1}{15}$ of that which would be required if the electric energy were converted into heat by resistance radiators. The question naturally is asked: "Why is not this suggestion utilized?" It is not the fault of thermodynamics, which tells us what we may expect, but it is the fault of the engineer who has not yet devised the suitable and necessary apparatus to effect these heat changes. We may also impose a portion of the blame on the economist, who states that at the present prices for electric power, other methods of generating heat are cheaper.

(2) In the realm of Chemistry the outstanding achievment in the application of thermodynamics is the pioneer monograph of Josiah Willard Gibbs, sometime Professor in Yale University. This paper has been considered by many scholars as one of the greatest works of genius. It is significant that no flaw has been found in this remarkable

piece of logical deduction. Many parts of the great work yet await interpretation in terms which are more generally understood than in the abstract and coldly logical form in which Gibbs expressed himself. Perhaps the outstanding single application to chemical research has been the guiding principle of the Phase Rule, a general statement connecting the *number* of different phases or homogeneous portions with the number of chemical individuals. Practically the whole of Inorganic Chemistry has been done over or is being done over in the light of this powerful generalization. The whole subject of metallic alloys has emerged from the shadows of empiricism to the clear light of logical interpretation. The classical investigations with which van't Hoff busied himself for many years, the conditions of the deposition of the great Stassfurt salt deposits of Germany, were always guided by the phase rule. The applications of the phase rule are legion.

Another guiding principle of the chemist is the logical outcome of these laws of thermodynamics. This is the so-called "mass law" which was first deduced on somewhat dubious grounds, but which now has a rigid proof based only on the validity of an equation describing the pressure-volume-temperature behavior of a gas, an equation which is as accurate as experiments can be made. This mass law formula is independent of any mechanistic theory of the constitution of matter. The principle of mass action is of varied application, one of which is the approach which it affords to the study of quantitative analysis.

I cannot pass from recounting the many contacts between energetics and chemistry without reminding you that the beautifully indefinite term "chemical affinity" receives a positive and quantitative meaning through the logic of thermodynamics. There have been in our scientific literature some marvellously convenient expressions, convenient because no precise meaning is stated and convenient because they concealed ignorance under an imposing array of verbiage. Affinity is one of those terms, catalysis is another, solid solution was formerly another. I cannot refrain from throwing a brick or two at our friends in other fields of learning. Try to define if you will the exact meaning of the terms: progress, democratic, the greatest good to the greatest number, terms as elusive in their line as the word affinity used to be in chemistry. In an early lesson in chemistry I was taught that oxygen and hydrogen unite with explosive violence because they have a great affinity for each other. Somehow this reason was about as convincing and satisfying as the feminine reason for going to the seashore rather than to the mountains in the summer, the plain and simple reason being *because*. Thermo-

dynamics makes the hazy idea of affinity definite and places it on a quantitative basis. It is possible to get work from the chemical union of hydrogen and oxygen. By just this maximum amount of work, hydrogen and oxygen together possess something which the product water does not possess. This available work is the measure of the chemical affinity of hydrogen and oxygen. So that a new and fruitful line of investigation has opened up, resulting in the preparation of tables of the chemical affinities, measured in terms of the work necessary to produce the change. Really, the tables are labelled by the more impressive name of free energy tables but the names are identical in their significance. About 200 of these chemical affinities have already been determined. Such a table will be of immediate and infallible service. By the simple use of pencil and paper we can settle the possibility or impossibility of any chemical change involving the substances whose affinities are listed. No reaction will spontaneously occur unless there is a loss of free energy. Credit should here be given to the ingenuity and industry of Lewis and Randall in collecting the necessary data from many sources, for their own experimental additions of new data and for the laborious calculations which are frequently necessary. These tables afford the data for finding whether a reaction is theoretically possible but since thermodynamics does not deal in mechanisms, no suggestion is offered regarding the velocity of the reaction, or of the methods of overcoming the natural inertia of things.

Such are some of the achievements of pure thermodynamics.

Mechanistic interpretations were appealed to quite early in the study of the physical sciences. In a beginning course in chemistry the first few lectures are devoted to a discussion of physical changes, chemical changes, mixtures and compounds. Then the prevailing theory of the structure of matter is announced, the atomic and molecular theories. The theory of atoms, first proposed by the ancient Greek philosophers, and revived by John Dalton about 120 years ago, offers a mechanical explanation for the multitude of facts concerning chemical combinations. The atomic theory is more firmly established now than ever before. It is true that some of the details of the theory which were at first confidently believed to be fundamental have been abandoned, and that other details entirely undreamed of by Dalton and others of his day have been added to this triumph of metaphysics. The belief in the *existence* of atoms is universal, but beliefs regarding the structure of atoms is even yet in a state of flux. The atomic theory, and its companion the molecular theory have done incalculable service in offering a metaphysical picture of the inner structure of matter.

Mechanistic ideas assert themselves in the kinetic theory of gases. Having postulated that there are atoms and molecules, the next question which was asked is: Are these things stationary or are they in motion? The kinetic theory asserts that gas molecules are in constant and rapid motion. Hydrogen gas molecules are said to be moving at an average rate of about one mile per second, and other molecules at slower rates. This theory attempts to account for many of the properties of matter which pure thermodynamics takes as its starting point. Thus the pressure which a gas exerts on the sides of a balloon is according to pure thermodynamics an experimentally determinable quantity but what the character of the pressure is, does not come within the field of phenomenology. The mechanistic kinetic theory states that the pressure is of the nature of a bombardment and that the pressure gauge records the integrated effect of all the blows delivered when the molecules strike and rebound from a given surface. The mechanists go even farther, for they apply the same laws of mechanics to molecules which hold for baseballs and planets. This mechanistic theory also attempts to state what heat is. The heat which a body possesses is the sum of the kinetic energies of the atoms and molecules within the body and of the potential energy of the parts due to their separation when attractive forces tend to bring the parts together. The mechanical theory of heat has been fruitful in suggesting numerous experiments by which its own validity can be tested out.

The successes of the mechanistic approach to the world around us have indeed been many. Some of the other current theories need only be mentioned: the theory of electrolytic dissociation, over which beginners in chemistry now struggle, the modern conception of electron and proton, the still more recent conception of the atomic character of energy itself or the quantum theory.

But in interpreting observed phenomena on a hypothetical, metaphysical basis we are liable to fall into several kinds of error. We are liable to forget that a certain mechanistic interpretation may not be real. The flat disk theory of the earth was a good working hypothesis and does afford a picture which is consistent with many of the observed phenomena. It was so good in hypothesis that it became the orthodox belief of the ecclesiastics, especially when Biblical texts were found which seemed to be in accord with their view. In this same connection a recent writer (Lindsay) has this to say: " . . . . having once chosen a hypothesis or group of them on which to base the development of a physical theory like that of atomic structure, one may, often almost im-

perceptibly, fall into the state of looking upon the system chosen as the only true reality. It is then that the discovery of some new phenomenon not easily explainable in terms of the original hypothesis injects temporary confusion into the science. Of this there are numerous illustrations in the development of physics. One commonly cited nowadays concerns the difficulties over matter in motion which arose from the use of the older metaphysics of absolute space and absolute time. A still more illuminating example is to be found in the woeful mix-up in our present ideas on the emission and propagation of radiant energy, a problem very closely bound up with that of atomic structure. The researches of the last century based on the hypothesis of the undulatory nature of light were so successful and led to the creation of such a well-established body of knowledge that it was hard to doubt the reality of it all,—this was gradually taken for granted by most physicists. It was for this reason that the discovery of the discontinuous nature of the emission of light has proved so disconcerting, for we are here dealing with phenomena which in no simple way have been subsumed under the wave theory, in spite of the many attempts that have been made to do so. The warning provided by this example is very plain: we must never be too ready to attribute complete reality to any one hypothesis no matter how satisfactorily it may appear to correlate known facts. There is always the chance that it may break down in a crucial experiment."

This same point is brought out so excellently in a recent book by that master physicist, Professor R. A. Millikan, that I have here a rather long quotation, in which Professor Millikan draws from his personal experience.

"The transition from the old to the new mode of thought in physics was probably made as dramatically in my case as in that of anyone in the world, for I was in the fortunate position of having entered the field just three years before the end of the complete dominance of nineteenth century modes of thought. In those three years I had the privilege of personally meeting and hearing lectures by the most outstanding creators of nineteenth century physics—Kelvin, Helmholtz, Boltzmann, Poincaré, Rayleigh, van't Hoff, Michelson, Ostwald, Lorentz—every one of whom I met and heard between 1892 and 1896. In one of these lectures I listened with rapt attention to the expression of a point of view which was undoubtedly held by most of them—indeed by practically all physicists of that epoch, for it had been given expression more than once by the most distinguished men of the nineteenth century.

"The speaker had reviewed, first, the establishment and definite proof of the principles of mechanics during the seventeenth and eighteenth centuries culminating in LaPlace's great Mechanique Céleste, then he had turned to the wonderfully complete verification of the wave theory of light by Young and Fresnel, between 1800 and 1830, experiments which laid secure foundations for the later structure known as the physics of the ether, one of the most beautiful products of nineteenth century thinking and experimenting, then he had traced the development in the middle of the century of the greatest and most fundamental generalization of all science, the principle of the conservation of energy, then he had spoken of the establishment in the first two decades of the second half of the century of the second law of thermodynamics, the principle of entropy or of the degradation of energy, and finally of the development by Maxwell of the electromagnetic theory and its experimental verification by Hertz in 1886, only seven years earlier than the date of the lecture. This theory abolished in all particulars except wave length the distinction between light and radiant heat and long electromagnetic waves, all these phenomena being included under the general head of the physics of the ether.

"Then, summarizing this wonderfully complete, well-verified, and all-inclusive set of laws and principles into which it seemed that all physical phenomena must forever fit, the speaker concluded that it was probable that all the great discoveries in physics had already been made and that future progress was to be looked for, not in bringing to light qualitatively new phenomena, but rather in making more exact quantitative measurements upon old phenomena.

"Just a little more than one year later, and before I had ceased pondering over the afore-mentioned lecture, I was present in Berlin on Christmas Eve, 1895, when Professor Roentgen presented to the German Physical Society his first x-ray photographs. Some of them were of the bones of his hand, others of coins and keys photographed through the opaque walls of a leather pocket-book, all clearly demonstrating that he had found some strange new rays which had the amazing property of penetrating as opaque an object as the human body and revealing on a photographic plate the skeleton of a living person.

"Here was a completely new phenomenon—a qualitatively new discovery having nothing to do with the principles of exact measurement. *As I listened and as the world listened, we all began to see that the nineteenth century physicists had taken themselves a little too seriously, that we had not come quite as near sounding the depths of the universe, even in the matter of fundamental physical principles, as we thought we had.*"

The present status of the radiation theory is to some very disconcerting and unsatisfactory, for there are current two representations of the phenomenon. When the *propagation* of light is being discussed the wave theory is eminently satisfactory, and when the *emission* of light is being discussed the quantum theory offers an easy explanation. This dual nature of the theory of light has been very stimulating to further research, and it may later appear that the two theories are not as antagonistic as now appears.

Certain of the chemists and of the physicists are not in accord over the theory of atomic structure. Again different kinds of phenomena appear to require different explanations. One mechanism of the atom is proposed to account for valence or the chemical combining capacity, and another mechanism is set up to account for radiation by atoms. Perhaps some genius will come forward and reconcile the two views.

You can doubtless draw the moral of this sketch as well as I can. The phenomenologist observes facts and generalizes from the accumulated data. Frequently he may be at a loss to know what observations to make or what apparatus to build to give data worthy of record. It appears to be necessary for the great mass of us to join the ranks of the mechanists. Then we can bring our imaginations into service, guess a mechanism by which things may work, and then devise decisive experiments to test out the theoretical mechanism. Such tests will give certain final results in case the experiment fails to support the theory: The theory was wrong. But on the other hand the accord of experiment and theory is not final proof of the validity of the theory, for there may be other theories just as good or even better in explaining the observations. It is only when all other conceivable theories fail to accord with the facts that the particular theory becomes reality. The mechanist must interpret with extreme caution.

Physical science at the present time seems to be dominated by the mechanists. It is indeed fortunate that opinions and theories are frankly altered or abandoned when the facts are not in accord. The retention of rival theories of atomic structure or of radiation is merely evidence of laudable caution and of the true scientific spirit.

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SOME EFFECTS OF THE INJECTION OF PITUITRIN INTO HENS' EGGS

A Preliminary Report

By Bert Cunningham and W. Stanfield

It has already been shown by the senior author that the relative growth rate of the embryonic chick can be accelerated by the use of compressed air.[1] For several reasons, chiefly inadequate apparatus, but possibly also for other reasons to be pointed out in a later paper, chicks have never been hatched under pressure.

Having found that acceleration can be accomplished by pressure independently of heat, other agents of acceleration were sought.

Some four years ago the senior author injected pituitrin into the albumen of hens' eggs, but the eggs were soon heavily invaded with mold. Later, eggs were injected under the most sanitary conditions available and the hole in the shell plugged with ether alcohol parlodion. These eggs, which were injected before incubation was begun, remained free from infection but showed great abnormalities and but little development. Since that time some fifty eggs have been injected before incubation and in no case has there been the semblance of development beyond the 2–3 day stages.

Injections were then tried on the seventh day and the eggs opened upon the ninth. In this case, as in all the following cases, 1 cc. of solution prepared by diluting 1 cc. of commercial obstetrical pituitrin to 50 cc. with distilled water was the most satisfactory. In many cases the embryos were alive and normal.

Pituitrin Injection

Injection on 7th day, eggs opened on 9th day

Total eggs injected	98
Infertile	30
Dead in shell	10
Abnormal embryos	19
Normal embryos	39

[1] Journ. E. M. Sci. Soc. **42**: 188–192. 1927.

Total check eggs	52
Infertile	7
Dead in shell	2
Abnormal embryos	3
Normal embryos	40
Average weight of injected embryos	1901 mg.
Average weight of check embryos	1578 mg.

Later, chicks injected on the seventh day were hatched. A considerable portion of these appeared to be perfectly normal and their later development compares favorably with the check chicks.

Pituitrin Injection

Injection on 7th day, eggs hatched

Total eggs injected	66
Infertile	23
Abnormal and dead in shell	23
Chicks hatched	20
Total check eggs	28
Infertile	5
Abnormal and dead in shell	4
Chicks hatched	19
Average weight of injected chicks	40.7 gr.
Average weight of check chicks	41.1 gr.

A second set of experiments in which the eggs were incubated in a "commercial incubator" along with many other eggs gave more interesting results. These are tabulated below.

Pituitrin injection

Injection on 7th day, eggs allowed to hatch. Incubated in commercial incubator

Total eggs injected	38
Infertile	8
Bacteria	7
Abnormal embryos	4
Normal chicks	14
Abnormal chicks	5
Average weight of injected chicks	40.0 gr.
Average weight of check chicks (14 taken at random)	37.4 gr.

Here there is considerable difference in favor of the injected egg.

One set of eggs was injected on the sixth day and opened on the eighth. This appears to be a more favorable period for injection, but the number of cases is too small to be positive.

Pituitrin Injection

Injection on the 6th day, eggs opened on 8th day

Total eggs injected	18
Infertile	6
Abnormal and dead in shell	7
Normal	5
Total check eggs	6
Infertile	1
Normal	5
Average weight of injected embryos	1203 mg.
Average weight of check embryos	950 mg.

From these experiments it was found that

1. Injection before incubation prevents the development of the egg.
2. Injections of pituitrin increase the rate of growth in early development.
3. It produces a decrease of a hatching weight in many cases as compared to check eggs, but in the commercial incubators, where conditions were more favorable, it gives a decided increase.
4. It has no effect on the final time requirement of twenty-one days for hatching.

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TWO NEW TERRAPINS OF THE GENUS PSEUDEMYS FROM THE SOUTHERN STATES

By C. S. Brimley

Plates 1 and 2

Having again taken up during the past two years the study of turtles, I have had to get a number of specimens from the Southern States and in the course of events two apparently new species have turned up.

The genus *Pseudemys* includes large terrapins, most of the species attaining a length of a foot or more in shell and weight of seven to fifteen pounds. The carapace is in young specimens very plentifully marked with a complicated pattern of yellow lines, which varies somewhat in the different species, but in the adults this pattern may be almost wholly lost in some species, very much reduced and altered in others, and practically persistent in its entirety in still others.

The two species described herein both belong to the *concinna* group of the subgenus *Pseudemys* Gray (*Ptychemus* Agassiz) and therefore have the lower jaw serrate, the upper jaw without notch or cusps at the symphisis, and the ridges in the masticating surface of the jaws tuberculate.

Both differ from the other forms of the group known to me by having dark markings on the plastron as well as in other characters. One is from North Carolina, the other from Louisiana.

Pseudemys vioscana n.sp. Viosca's Terrapin

Plate 2, fig. 2

Male. Carapace dark brown with the reticulated pattern of *concinna* evident but only the larger yellow lines conspicuous, the rest obsolete or wanting; marginals with a vertical yellow line on each, the intervening concentric markings wanting; large dark blotches present on the underside of all the marginals; two longitudinal dark bands on the bridge, and dark blotches on the inguinals and axillaries; plastron with a prominent dark pattern, the dark markings mainly along the transverse sutures, forming a broad V-shaped mark on the gulars, urn-shaped figures on the humerals, a broad stripe along each transverse edge of the pectorals,

PLATE 1

PSEUDEMYS ELONAE. No. 128, ♂ Carapace. Elon College, N. C.

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PLATE 2

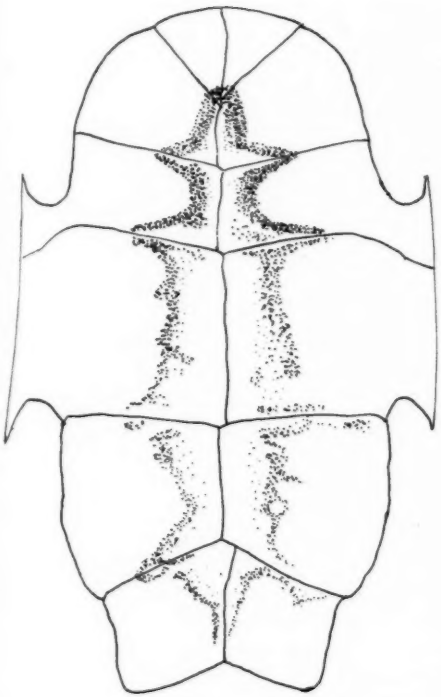

FIG. 1

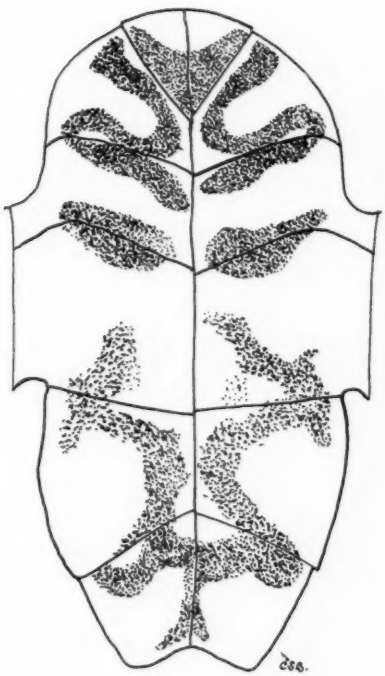

FIG. 2

FIG. 1. PSEUDEMYS ELONAE ♂, No. 124, Plastron. Elon College, N. C.
FIG. 2. PSEUDEMYS VIOSCANA ♂, No. 115, Plastron. Lake Des Allemands, La.

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another along the anterior edge of the abdominals, and an oblique mark on their posterior portion, a broad curved mark on each femoral, and an irregular transverse band across the subcaudals. Head and legs with yellow lines, those on the head more reduced than in *concinna*.

Shell nearly smooth with rather faint longitudinal wrinkles on the costal plates and an evident keel on the last three dorsals. Ridges in alveolar surface of upper jaw with well developed conical tooth-like tubercles in both anterior and posterior portions. Length 8¼ inches.

Other specimens ranging from 6 to 12 inches long show considerable variation in the dark markings of the plastron which, however, are always present on the four anterior plates and almost always on the posterior pair, the largest female (11 inches) has the yellow markings on the carapace still more reduced than in the type, even the vertical bars on the marginals being absent on the four posterior pairs, while the largest male (12 inches) has the pattern somewhat better developed than in the type. Smaller specimens (6 inches) have the yellow pattern much more evident, but never as clear as in *concinna*, and there are confused markings between the vertical bars on the marginals.

The shell is much higher and more arched than in *concinna* especially in the larger specimens, and in all there is an evident keel on at least the last dorsal plate and usually on the last two or three.

Type, mounted specimen No. 115, male, Lake Des Allemands, La.; paratypes, Nos. 111, 114, mounted females, 106, 107, mounted males, 112, 113, male shells with heads, 7807–7811, wet preserved specimens, eleven paratypes in all, all taken by Dr. Percy Viosca, Jr., at same place as type in April 1927.

I have also a single male (shell with head) from same locality, taken by Dr. Viosca, April 9, 1921, which has the plastron wholly without markings and which may (or may not) be the same species. It does not differ essentially from *vioscana* except as to the unmarked plastron.

Pseudemys elonae n.sp. ELON TERRAPIN

Plate 1 and plate 2, fig. 1

Male. In general similar to *Pseudemys concinna* Leconte, but differing in having a dark figure down the center of the plastron and in the alveolar ridges being less strongly tuberculate. The pattern of the carapace is black and yellow, reticulated as in *concinna*, and is very distinct. The underside of the marginals is more heavily marked with black than in my specimens of *concinna*, dark blotches being present on

most of the plates, but only those on the bridge and near it have the large round blotches on the sutures, upper surface of marginals with the usual vertical median yellow bar and concentric yellow lines around the sutures. An irregular dark longitudinal band on the bridge and dark blotches on the inguinals and axillaries. Plastron yellow with dusky markings along the central longitudinal suture, beginning a little more than half way down the gulars, extending as a single unbroken band on both sides of the suture nearly to the pectorals, then dividing into a dusky band on each side of the suture, which continue more or less distinctly to the subcaudals, where the two reunite and continue so practically to the posterior edge of the shell, a broad extension runs on each side along the sutures between the femorals and subcaudals. Head and leg markings as in *concinna*.

Upper jaw smooth edged without notch at symphisis, lower jaw strongly serrate, alveolar ridges in upper jaw without conical tubercles, in their posterior portion and with those in the anterior portion poorly developed.

Carapace nearly smooth with longitudinal grooves on the costal plates, depressed somewhat on each side of the median line on the third and fourth dorsals leaving a faint median keel between the depressions, a faint keel also on the fifth dorsal. Length of shell nine inches.

Type, a mounted specimen, No. 124, collection of C. S. Brimley, from a pond in Guilford County, North Carolina, not far from Elon College, in the Cape Fear drainage, taken in a fyke net by Messrs. D. W. Rumbold and F. J. Holl of Duke University.

Allotype female, No. 130, C.S.B., taken at same time and place, length 12 inches, weight 6½ pounds, differs but little except that the markings on the carapace are slightly less developed, and the longitudinal dusky bands on the plastron are separated for their whole length and send off branches of varying length along each side of the gular-humeral, abdominal-femoral, and femoral-subcaudal sutures, concentric yellow markings between the vertical yellow bars present on all upper marginals.

Paratype male, No. 128, C.S.B., same date and locality, has markings on carapace somewhat broken, length 9 inches, paratype female, No. 127, C.S.B., length 7¼ inches, has very heavy yellow markings almost obscuring the ground color of the carapace, dusky pattern of plastron only present on first two pairs of plates.

Besides the specimens already named, I saw several more in November 1927 that had been taken at the same time and place including two hatched that year, these last were similar to the young of *concinna* but

had traces of black at the inner angles of the gular and humeral plates. I also saw five adults caught in mid March 1928. None differed materially from those described except that two large females had the plastron almost black from a stain or deposit on the shell. The allotype female was in the same condition when I first saw it in November 1927 but the deposit had nearly worn off when it came into my possession in March 1928 and the remains were easily scraped off. Messrs. Holl and Rumbold told me they found only the remains of filamentous algae in the alimentary canal, showing the species to be a plant feeder, and this is confirmed by the fact that the alimentary canal of the allotype female was eight feet long.

I wish to express my thanks to Dr. Percy Viosca for the gift of all the specimens of *P. vioscana*, and to Messrs. Holl and Rumbold for the gift of the *P. elonae*.

The types will ultimately be placed in the United States National Museum.

DEPARTMENT OF AGRICULTURE,
RALEIGH, N. C.

QUALITY OF THE SURFACE WATERS OF NORTH CAROLINA

By E. E. Randolph

Water is as essential to industry as it is to life. It is the ultimate source of power from the waterfall or from steam. Especially in chemical industries it is vital to production. It must be supplied in abundance and of the required quality.

The quality of water is determined by the materials which are in suspension or in solution. All are familiar with the effects of hardness in such matters as boiler scale or in laundry work. In the complexities of modern chemical manufacture certain impurities in the water become serious. Hence many industries are very exacting in their requirements for the quality of water. To illustrate:

To manufacture a ton of paper about 50,000 gallons of water are used. In the digestion of the pulp the alkalies precipitate ferric hydroxide. This deposited iron salt gives a brown color to the pulp and paper. Bleaching does not remove these splotches. In sizing aluminum resinate is precipitated on the fibers. Hard water precipitates calcium resinate, a substance which does not adhere well to the fiber. Alkalies prevent the formation of the aluminum resinate. Acid water corrodes the screens and disturbs the size and the dyes. Turbidity protects the fibers from the even dyeing or bleaching.

Water for dyeing and bleaching must be free from suspended matter, soft, and free from iron. For light shade dyeing iron is disastrous. Tannin mordants are impossible with iron water. Calcium and magnesium coat over parts of the fiber and cause uneven dying and splotches. This fiber coating is almost impossible to remove. It makes the fibers harsh, adsorbs colored pigments which are hard to free from the goods.

In tanning lime water removes the hair and the fatty tissue from the hide. If carbonic acid is present calcium carbonate is precipitated compactly on the hide so that uniform tanning is prevented. Iron unites with the tannin to make a black ink, so that black leather only can be made in iron water. Chlorides interfere with the plumping process but sulphates aid in this operation. Organic matter must be avoided. These illustrations indicate how carefully chemical indus-

tries must be to find suitable water or to properly treat their water which may not be entirely suited to their needs.

During the past twenty years North Carolina has been rapidly transformed into a great manufacturing state and is now the center of the industrial development of the South. Various factors have contributed to this transformation from an almost exclusively agricultural to a rapidly increasing manufacturing activity. Not the least among these factors is the excellent water of the state. It has been the deciding factor in the location in this state of such industries as rayon manufacturing, bleacheries, dyeing and sizing plants, tanning, and paper making.

A number of industrial organizations in recent years have been considering North Carolina as the suitable location for their industries. Inquiries from many of these business organizations have made clear the fact that no extensive information about the quality of water of the state has been available. During the past few years large and wholesome industries were located in other states because they could not find immediately available convincing information about the industrial waters of this state. To meet this need the writer suggested to Major Wade H. Phillips, the Director of the Department of Conservation and Development, that an industrial survey be made of the quality of surface waters of the state. The result of this survey is now in the hands of the printers. This report includes the complete industrial analyses of 200 samples of water from all of the rivers and several of the larger creeks at various points along their courses. Over a hundred of these analyses were made by the writer in the chemical engineering laboratory of State College, and nearly a hundred were made by the Quality of Water Division of the United States Geological Survey. The samples of water were collected by Professors Saville and Ray of the Water Resources Division of the State Department of Conservation and Development. This bulletin was prepared by Mr. Ray and the writer.

PROCEDURE EMPLOYED

Samples were collected in sample bottles of one gallon capacity and shipped in especially prepared containers having brace strips in the corners of the box held firmly against the bottle at the top and bottom by springs. These cases proved to be so satisfactory that not a single bottle was broken in transportation.

The methods of analysis are those employed by the United States Geological Survey which are in the main identical with those suggested in "Standard Methods." The samples were collected at fairly regular

intervals so that the analyses could be made as soon as the samples arrived at the laboratory. The alkalinity was determined as soon as the bottles were opened. For the purpose of analysis one liter of the water was evaporated to dryness. The total residue was noted as a comparative check on individual results obtained later.

The factors determined in these analyses include in parts per million the silica, iron, calcium, magnesium, sodium, potassium, carbonates, bicarbonates, sulphates, chlorides, nitrates, the total of these constituents dissolved, the suspended matter, turbidity, calculated hardness and soap hardness, color and alkalinity.

The results of the analyses were all checked by the milligram equivalent method used by the Geological Survey.

The suspended matter was determined by filtering a liter of the water through asbestos mats in Gooch crucible. One liter of this filtered water was evaporated to dryness (in platinum dish) and brought to constant weight at 180°C. This weight of dissolved solids served as a check on the totals of radicals found. This residue was evaporated to dryness with hydrochloric acid, taken up with water and a few drops of hydrochloric acid, filtered, dried, ignited, and volatilized with hydrofluoric acid. The aluminum and iron were precipitated from the filtrate, filtered, dissolved, and the iron was determined colorimetrically. In the filtrate from the ammonia calcium was precipitated as the oxalate and the excess was titrated with standard permanganate. Magnesium was precipitated in the cooled solution with ammonium and sodium phosphate and weighed as magnesium pyrophosphate. Another liter was evaporated and the silica was removed. Then ammonium carbonate was added, heated, and filtered several times. The alkalies were determined as chlorides. From these potassium was precipitated with platinic chloride, washed with 80 per cent alcohol, dissolved and reduced to metallic platinum with pure magnesium. From the amount of dried platinum the amount of potash present was calculated.

CHEMICAL CHARACTER OF NORTH CAROLINA WATERS

The chemical nature of the water is shown by the tables and by graphical diagrams. The waters may generally be divided into three classes corresponding somewhat to the three geographical divisions of the state. The waters of the whole state as a rule are low in mineral content, unusually soft, and are slightly alkaline. Very few acid waters are found. Of the dissolved matter silica, calcium, and bicarbonate are higher than other constituents. Sodium, sulphate and chloride are low.

The waters of the mountain division are clear, have little turbidity, no acidity, and little alkalinity. The waters are so clear that Asheville, the largest city of the division, for a long time did not even have a filter plant. Twenty-four towns still do not have filter plants because their water sheds are uninhabited and the waters are clear. The average amount of dissolved solids ranges from between 20 to 30 parts per million of total dissolved solids. For these reasons and others one of the largest paper mills in the country is located here, several large tanneries and one of the largest bleacheries in the United States are doing a profitable business in the western division.

In the piedmont division the land is more generally cultivated and the rains carry more silt and mud into the streams and the turbidity increases making it necessary for the water to be filtered with simple alum flocculation and sand filters. The water is soft and of low mineral content. Since the water has been in contact with the ground a longer period than in the mountain division on account of the topography of the country we expect to find the dissolved mineral matter higher than it is in the mountain section. From 45 to 65 parts per million of dissolved solids are found. The average calcium is from 4 to 6 parts per million; magnesium 1 to 3 parts per million, making a hardness of not over an average of 14 to 24 parts per million; bicarbonates from 20 to 30 parts per million. The iron content is low. The quality of this water is attested by the fact that the center of the great textile industry in the state and in the United States is largely located in the piedmont belt.

The waters of the coastal plain average about the same as those of the piedmont section. The turbidity is somewhat higher and the color of certain waters is noticeable. This color, however, even in these cases is largely removed by the usual filtration process. The color is derived from the vegetable matter. The surface waters of this belt are soft and contain about 50 to 70 parts dissolved solids per million.

A few localities are supplied with water from deep wells. Those immediately along the coast are higher in saline content. In the marl beds and limestone areas the water contains a higher percent of lime. These areas are limited to certain districts, however. As would be expected, some of the deep well supplies contain a larger amount of sodium chloride and bicarbonate.

PURPOSES OF THE SURVEY

The reasons that this work was undertaken are:

First, To obtain definite information about the quality of the surface waters throughout the state;

Second, To make this information available for prospective builders of industries in the state, and;

Third, To discover whether any of the waters need corrective treatment for specific manufacturing purposes.

STATE COLLEGE,
RALEIGH, N. C.

SPORE-FORMING, GAS-PRODUCING AEROBES IN WATER

By Roy J. Campbell

It so happened that last summer in Chicago I did considerable work on a spore-forming, gas-producing aerobe which, unless care was taken, was liable to give false results in water analysis by the bacteriological method. They were obtained by heating the material to be examined for ten minutes at eighty degrees centigrade. They formed acid and gas in dextrose and lactose. They were all non-motile, formed acid followed by coagulation in milk; reduced the milk sugars and caused peptonization in five to eight days; grew to a slight extent in tubes with oxygen removed by pyrogallic acid and sodium hydroxide, also in deep agar; gave negative indol, nitrite, and methyl red tests. Agar colonies were small, smooth, convex, and regular in outline. Endo colonies were similar but were deep red in color and colored the medium. If on the plates one found small "dew drop" colonies of the color mentioned they were always found to be the type in question. Liquefaction occurred in gelatin. On agar slants the growth was moderate, filiform, and echinulate. When treated with Grams' method the organisms failed to destain unless decolorized six to ten minutes and even then some of the organisms retained the stain. The spores when treated by Grams' method retained the stain.

At the beginning of the work the following samples were tested:

NUMBER OF SAMPLES	MATERIAL
18	Water
4	Urine
18	Animal excrement
21	Leaves from trees and shrubs
12	Grass
9	Street dirt
14	Soil
12	Mud from lake bottom
9	Beach sand

All of them proved to be negative with the exception of one soil and four samples of beach sand. Thus the organism in question was found five

times in one hundred and twenty seven samples of material. In each case the sample was collected in a sterile tube and dextrose and lactose fermentation tubes inoculated. The tubes were then heated as stated above for ten minutes at eighty degrees and incubated for twenty-four hours. At the end of that time plates of Endo medium, and sometimes of nutrient agar, were streaked with a loop of material from the tubes which showed gas production. At the end of another twenty-four hours the plates were examined and if typical colonies were found dextrose and lactose tubes were again inoculated to confirm the findings by fermentation. The plates were allowed to stand in the meantime and the following day the colonies from which material had been fished were examined for spores. Of course practically all of the plates streaked showed bacterial growth, chief among which was *subtilis*. However, this and other types could be readily distinguished from the discrete colonies of the aerobe which could be readily fished.

Twenty-eight samples were then collected from each of two beaches, one where bathing was not allowed and one where there was a great deal of bathing. It so happened that in each case four samples gave positive and twenty-four negative results. Thirty-eight samples were then collected from each beach. Some of these were taken in or near the water, others collected farther up the beach in dry sand. The table below shows the results obtained.

	BEACH, NO BATHING		BEACH, BATHING	
	Moist sand	Dry sand	Moist sand	Dry sand
Total	20	18	14	24
Positive	1	1	0	2
Negative	19	17	14	21

Thus once more was their presence confirmed. It should be noted that positive results were obtained more often from dry sand. Of twenty-five samples of moist sand subsequently collected all were negative. A beach used for bathing shows no more positives than one where bathing is prohibited.

Rabbits were immunized against two of the strains by means of intraperitoneal injections. No immediate ill effects were noted but the rabbits gradually lost weight. The agglutination and precipitin tests are shown in the tables on following page.

AGGLUTINATION TESTS, SERUM FROM RABBIT IMMUNIZED WITH 16 B

	DILUTION												
	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512	1:1024	1:2048	1:4096	1:8192	Control
16 B	+	+	+	+	+	+	+	+	+	+	+	+	−
4 E	+	+	+	+	+	+	−	−	−	−	−	−	−
9	+	+	+	+	+	+	+	+	−	−	−	−	−
4	+	+	+	+	−	−	−	−	−	−	−	−	−
7	+	+	+	+	+	+	+	+	+	+	+	−	−
16	+	+	+	+	+	+	+	+	−	−	−	−	−

AGGLUTINATION TESTS, SERUM FROM RABBIT IMMUNIZED WITH 10 C

	DILUTION												
	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512	1:1024	1:2048	1:4096	1:8192	Control
10 C	+	+	+	+	+	+	+	+	−	−	−	−	−
4	+	+	+	+	+	+	+	+	+	+	−	−	−
6	+	+	+	+	+	+	+	+	+	−	−	−	−
9	+	+	+	+	+	+	−	−	−	−	−	−	−
16 B	+	+	+	+	+	+	+	+	+	−	−	−	−
4 E	+	+	+	+	+	+	+	+	−	−	−	−	−

PRECIPITIN REACTION

	IMMUNIZED WITH 16 B						IMMUNIZED WITH 10 C				
	Dilution						Dilution				
	1:0	1:2	1:4	1:8	1:16		1:0	1:2	1:4	1:8	1:16
16 B	+	+	+	+	−	16 B	+	+	+	−	−
2	+	+	+	+	−	6	+	+	−	−	−
9	+	+	+	+	−	8	+	+	+	−	−
4	+	+	−	−	−	4	+	+	−	−	−
8	+	+	+	+	−	7	+	+	+	−	−
4 C	+	+	+	+	−	5	+	+	−	−	−

Brilliant green when added in amounts of 0.3 cc. of a 0.1 per cent solution to 100 cc. of agar did not inhibit the growth of these bacteria. However, 0.6 cc. of the same solution did prevent their growth.

Gentian violet when added in amounts of 1 cc. of a 1:100 dilution

to 100 cc. of agar prevented the growth of practically all cultures and larger amounts did so.

Cultures inoculated into 3 per cent glycerine broth produced gas and in most cases an acid reaction. Two of the cultures were grown on blood agar plates and both of them were strongly hemolytic.

Dextrose and lactose tubes containing mixed cultures of *B. coli* and the aerobic spore-forming, gas-producer resembled a pure culture of either. Both gas and acid were produced. Milk inoculated with mixed cultures produced acid and coagulation occurred, sometimes with a moderate shredding of the casein. Evidently one type does not inhibit the other.

In North Carolina, in the vicinity of Winston-Salem, ninety tests have been made to determine whether or not the organism in question is indigenous to the region. Fifty samples of soil were taken from fields and wooded regions, thirteen from gardens, and twenty-seven from several different streams, However, not a single positive was found. If an organism of the type described should be found by workers in bacteriology in North Carolina the writer would be glad to be so informed.

SALEM COLLEGE
WINSTON-SALEM, N. C.

LITERATURE REFERENCES

EWING, C. Am. Journ. Pub. Health **9:** 257. 1919.
HAVENS, L. C., AND DEHLER, SOPHIA A. Am. Journ. Hygiene **3:** 296. 1923.
HINMAN, J. J. Journ. Am. Water Works Assoc. **7:** 821. 1920.
HINMAN, J. J., AND LEVINE, M. Journ. Am. Water Works Assoc. **9:** 330. 1922.
LISK, HENRIETTA. Journ. Am. Water Works Assoc. **10:** 139. 1923.
MEYER, C. M. Journ. Bact. **3:** 9. 1918.
NORTON, J. F., AND WEIGHT, J. J. Am. Journ. Pub. Health **14:** 1019. 1924.
ROAB, FRANK. Journ. Am. Water Works Assoc. **10:** 1051. 1923.

CELL BEHAVIOR IN THE REGENERATION OF SPONGES FROM DISSOCIATED CELLS[1]

By H. V. Wilson and J. T. Penney

The experimental part of this investigation was carried on during the past summer at the Beaufort (N. C.) Laboratory of the United States Bureau of Fisheries. For the privilege of working at this admirable station and for courtesies during their stay the writers are indebted to the Commissioner, Hon. Henry O'Malley, and to the Director, Dr. S. F. Hildebrand. The well known species, *Microciona prolifera*, was used. The cells were studied in several ways: *in situ* in living slices and in sections (paraffine, celloidin, frozen) of preserved material of the normal adult; in macerations of the adult; after expression from the sponge, alive and fixed; during reunition and the metamorphosis of the reunition mass, alive, in macerations and in sections and whole mounts of fixed material.

The investigation is by no means completed but certain results, which may here be briefly stated, have been reached. The normal adult contains the following types of cells and epitheloid membranes:

1. Mesenchyme cells with small nonnucleolate nucleus; cytoplasmic granules numerous, uniform in appearance (grayish in the living), and about 1μ diam.; cell when contracted commonly 8–9μ diam.; abundant everywhere.

2. Mesenchyme cells with large nucleolate nucleus; cell inclusions rounded, numerous in the larger cells, scanty or absent in the smaller, ranging from 4μ diam. down to minute ones, many of them of an orange color in the living; cell often elongated and reaching 30 x 7μ but many smaller sizes occur; abundant everywhere.

3. Mesenchyme cells with small nonnucleolate nucleus; cell inclusions numerous, deeply staining with haematoxylin, often rod-shaped; cells usually elongated and often branched, reaching 40 x 7μ; distributed throughout mesenchyme.

[1] The investigation has been prosecuted with the aid of a grant from the Rockefeller Fund for the Advancement of Research in the University of North Carolina.

4. Mesenchyme cells with very small nucleus, smaller than that of the collar cell; one conspicuous large, usually ellipsoidal, homogeneous inclusion and other smaller inconspicuous inclusions; cell elongated, reaching 25 x 6μ; abundant in the dermal membrane but occurring also in the general mesenchyme.

5. Mesenchyme cells, very slender and elongated such as occur commonly in the dermal membrane of many sponges and are usually known as fiber cells.

6. Germ cells. A few cells were met with in the mesenchyme, which seemed unquestionably to be immature ova. Sperm cells were not certainly recognized.

7. Collar cells; cell body rounded or polyhedral, about 4μ diam., nucleus about 2μ diam.; one or two conspicuous, very small, cytoplasmic granules of a red color to be seen in the living. The flagellated chambers make up a large part of this sponge.

8. The epidermis is made up of a very thin protoplasmic sheet, often appearing finely granular but again minutely reticular, studded with irregularly distributed nonnucleolate nuclei, smaller than those of cell (2) but larger than those of cell (1). Cell outlines have been looked for in a variety of ways but none have been discovered although deceptive appearances have not infrequently been had. The canals are lined with similar epitheloid membranes.

9. The spicules of course have adhering to them the usual small nucleated masses of protoplasm. Whether the horny fibers are immediately surrounded by any mesenchyme cells not assignable to the categories listed above, we leave for the present an open question.

The great bulk of the material (dissociated cells) that is expressed from the sponge is made up of mesenchyme cells belonging to classes (1) and (2), and collar cells, either singly or forming bits of chambers or indeed entire chambers. All three components are very abundant. Reunition takes place, on contact, between them all and certainly the bulk of a reunition mass is made up of the three classes of cells.

During metamorphosis collar cells have been found in, at any rate considerable, abundance in late as well as early stages and no direct evidence of phagocytosis has yet been had.

Whenever and wherever preparations of the reunition masses have admitted of critical examination with an immersion objective, the cells have been found to be abundantly interconnected, commonly by slender protoplasmic strands. The masses would thus seem to have a structure which must be classed as syncytial. But this structure is less homoge-

neous than the senior writer inclined to believe it in his earlier papers (1907, 1911). As to cellular dedifferentiation the only positive evidence we have as yet found concerns the collar cells which exist in the reunition body before metamorphosis as small compact masses without collar or flagellum, scattered or in irregular, solid groups.

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INTERSPECIFIC GRAFTING, USING SPONGE CELLS

By M. W. de Laubenfels

Grafting has formed one important phase of experimental biology. Among zoological examples may be mentioned the following. Harrison grafted together supplementary portions of tadpoles of two species and obtained composite frogs; Crampton similarly united portions of pupae of two different genera and secured conglomerated moths; Joest experimented extensively with interspecific grafts using earthworms, and Wetzel with united fragments of different species of Hydra. The testimony of this research is that the introduced tissue tends to be reduced in importance as growth proceeds, and that, as in the well known cases of grafts using plants, while the two species involved may pass along definite products of solid, liquid, or gaseous nature to each other, they have no other reciprocal effect.

What would be the effect could cells be introduced in among cells to form a more intimate interspecific graft? It has proven possible, using sponge cells, to secure viable conglomerates with two species of cells well mixed. The results so-far obtained are comparable in part with those of the researches mentioned above, but in this case there is evidence of effects between the species which may be somewhat different from those produced by the introduction of larger cell-masses.

Thanks to the joint courtesies of Professor H. V. Wilson (of the University of North Carolina) and of the Carnegie Institution of Washington, the writer was privileged to work at the Tortugas laboratory during the summer of 1927. In 1925 Professor Wilson demonstrated the value for biological research of certain sponges easily obtained at this station; taking advantage of his discoveries numerous experiments were performed with three species, selected for the ability of their cells to reunite into more or less perfect sponges following expression through bolting silk. These sponges are all of the order Demospongiae, but are certainly not closely related. Each, when squeezed in small bags of bolting cloth, yields three categories of cells, as follows:

A. Amoeboid cells, 7 to 14 micra in diameter, containing pigmented granules responsible for the color of the sponge, and therefore easily

recognized from each other even in mixtures, as these colors were respectively bright red, yellow-green, and dark purple. In unstained preserved material they are respectively yellow-brown, colorless, and purplish-brown, so that it is still possible to distinguish them.

B. Amoeboid cells of about the same size, but with much less distinct cell boundaries; they were translucent pale greenish, and could not be distinguished from each other in interspecific mixtures. The two types were of approximately equal abundance.

C. Cells from 2 to 4 micra in diameter, of which many were flagellate for some minutes after expressing. These latter retracted the flagellae, however, and were then indistinguishable from those that were non-flagellate from the first; all became feebly amoeboid. There were slight differences between those of different species, but these were so faint as to be worthless for differentiating kinds in inter-specific mixtures.

Expressed cells of all three types joined with others of their own species when their movements brought them into contact, and the groups contained the pseudopodial movements. In much less than an hour there remained practically no solitary cells, instead there were continuous masses of pale protoplasm thickly speckled with pigmented cells. These masses were loosely attached to the glass in sheets which might be continuous, or fenestrated so as to produce a reticulate appearance. There was often a tendency, apparently correlated with the bacterial environment, to pull loose from the substratum and curl up into balls. If these were over 1.5 mm. in diameter they quickly died, apparently due to smothering of the interior cells. Cutting with crossed needles was resorted to, to keep down the size. Within two to four days some of the balls sent out basal membranes and reattached to the glass. These, and the sheets that never pulled loose, often metamorphosed into little sponge masses with flagellate chambers and other indications that they were functioning as to ordinary sponges. Some that failed to attach lived as much as two weeks, but did not metamorphose.

It may be well to mention that the water temperature at Tortugas stays near 90 degrees Fahrenheit, and as a result vigorous bacterial activity, with haziness of cell outlines, plus odors, serves as a prompt post-mortem symptom and criterion of the moribund condition.

With regard to the metamorphic process referred to above, the purple species yielded the best results; at the end of twenty-eight days after expressing, many of its cell masses were still alive and flourishing, having the chambers, canals, and even erect cloacal tubes to indicate

that they were functioning sponges. The yellow-green species went rapidly through the stages up to the formation of the cloacae, all this in 6 to 8 days, but then always died. A test carried out late in the season seemed to indicate that this mortality was a result of a lack of adequate light. The regenerating masses of the red species stayed alive as much as one week, but showed very little indication of metamorphosis before dying.

Expressed cells of the three sorts were mixed, but the masses that ensued were always distinctly red, green, and purple, respectively. Such balls of tissue were brought together in various ways, and occasionally stuck lightly to each other, but gave no indication of anything worthy of being called fusion.

As noted above, it was observed that the active amoeboid cells showed nice discrimination in uniting only with others of their own species. It was further observed that they did not become amoeboid until reaching the sub-stratum. This led to a query as to whether they were similarly selective immediately after being torn from the adult sponge. Bits of adult sponge were cut into fragments about 2 to 4 mm. in diameter, and those of two species were mixed in one bolting-cloth bag. After much experiment, a moderately simple technique was devised, using the fingers for the requisite pressure, by which it was demonstrated that the freshly dislodged cells were not thus selective, but would attach to cells of other species. Using this process, interspecific conglomerations were secured, cells grafted in among cells.

The red-purple conglomerates were in flocculent masses 2 to 6 mm. in diameter, with very jagged outlines and places where they were quite thin. These were formed within a matter of seconds after the cells had passed through the bolting cloth, and long before the masses settled to the bottom of the beaker. There was little or no evidence of cell motility or change in outline of the masses as was so conspicuous with those of one species only. Direct observation of the thin areas, confirmed by study of sections, indicates that the red and purple cells were as thoroughly mixed as could be expected in pouring balls of two colours simultaneously into the same box.

The green-purple masses behaved much more nearly like monospecific re-uniting sponges, with much evidence of cell motility, especially in rounding up into balls with smooth contours. Observations of margins and sections showed, however, that there was some tendency for the purple cells to get together as a result of this activity; at the end of forty-eight hours the two colours might sometimes be made out

by the naked eye, though often a lens was required, the gross aspect remaining brown. Many experiments were carried out yielding data as to the relations between the degree of this sorting out, and various environmental factors. The size of the green-purple masses might be very large. As an experiment one was obtained a millimeter thick, and more than 2 by 4 cm. in area. Since the size could be controlled, that most favorable was encouraged, namely: about 1.5 mm. in diameter.

The red-green conglomerates formed rounded masses as soon as they could settle (some 15 minutes). These were rarely as large as 1 mm. diameter, commonly 0.1 mm., and were composed of cells so thoroughly mixed that neither the red nor the green was visible with the dissecting microscope, but only pale brown. These conglomerates would fuse with each other if brought together by needles, but were non-motile by themselves. Most of them died within a few hours of being expresed, and none lived quite two days. It will be noted that in both the conglomerations containing the red sponge there existed a a sort of cell paralysis of both species involved. This is one of the items indicating a possible fundamental difference between grafts of cells among cells as contrasted with the introduction of fewer but larger portions of tissue. This may be comparable with the harmful effect often observed when protoplasm of one species is injected into the blood or lymph of another.

The first two of the conglomerations mentioned above made attachment to the glass by putting out small, inconspicuous basal membranes, and were transferred to the ocean in "live-cars" for further study.

In the case of the green-purple mixture there was then a gradual elimination of the green cells, probably correlated with the need which that species had for abundant light, and which was not discovered in time to be supplied. There remained masses of the purple species only, seemingly healthy and ready to continue metamorphosis, but very small (under 1 mm.).

At the end of two weeks after expressing, the red-purple conglomerates were preserved. At this time they were clearly still alive, indicated by bright colour, crisp cell outlines, and lack of bad odor. Furthermore, direct observation of the living material, which as mentioned, was very thin in places, showed flagellate chambers, the vital elements of functioning sponges. Sectioned material proves that these must have been comparatively rare, however, as I have not so far found any of them on my slides. It may be that they occurred only in places where a comparatively large number of cells of one species happened to

be together. Throughout the masses, as shown by the sections, there was thorough mixing of the two species, but much evidence of cell degeneracy, such as shrinkage, loss of granules, and rounding-up in shape.

Further research of this sort seems advisable. While the conglomerates are evidently much more delicate than mono-specific cultures, they are yet viable. Experience has already shown some improved methods for their care, and still more may be learned. It may be recalled that the need of one of the species for direct sun-light was not discovered until too late for application; with the proper environment this vigorous species may yield better results than those so far obtained. A decrease of the pH of the sea water used was found favorable to the early stages of the conglomerates. More may be done with similar chemical experimentation. Other species combinations may be found that are even better than those so far tried.

The writer wishes to call especial attention to the fact that thus far we have been dealing with cells that, particularly in the early stages of their re-uniting, are practically starving. We have all too little real knowledge of the nutrition of sponges. A great need exists for a nutrient solution so that growth of these masses may be stimulated, and experiments carried on under controlled conditions in the laboratory, where we must now use "live-cars" out in the ocean to keep the cell masses alive for any considerable length of time. It is quite possible that such a nutrient solution may be devised.

The definite points accomplished are as follows: It is possible to obtain coherent masses which are intimate mixtures of the cells of two species of sponge. It is possible to recognize cells of each species in these conglomerates, both in life and in preserved material. It is possible to keep such conglomerates alive at least two weeks, during which time they give slight, yet perceptible indications of progress towards becoming functional sponges.

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IODINE IN NORTH CAROLINA PUBLIC WATER SUPPLIES

By J. W. Perry

The hypothesis that goiter and cretinism is related to low iodine in food and drink was first advanced by Chatin in 1851. This idea has been firmly established by subsequent researches. Marine and Kimball (1921) observed about 10,000 Ohio school girls for about four years. To 4,000 of these enough iodine was given twice each year to saturate the thyroid. None of those without goiter at the start of the test developed a goiter, if they took the iodine. Of the remaining who took no iodine 27.6 per cent developed goiter. Sixty per cent of those having a goiter at the start of the tests and taking the iodine treatment systematically were cured, i.e., their thyroids returned to normal. The treatment used consisted in two grams of sodium iodide administered during two weeks repeated twice yearly, once in the spring and again in the fall. Even more startling results are reported from Switzerland where the goiter incidence among school children was decreased from 89 to 13 per cent through the use of chocolate candy containing iodine.

Other experiments on rats indicate that it is the iodine containing hormone of the thyroid which controls the rate of metabolism in the animal. Repeated tests have shown that an increased amount of this hormone will speed up the rate of metabolism and cause certain changes in the size of the various organs. A decrease in the amount of thyroid hormone will cause a decrease in the metabolic rate as high as 30 per cent. From these experiments we may conclude that the normal function of the thyroid gland is to control the rate of metabolism through its hormone thyroxin. Thyroin is approximately 65 per cent iodine.

The source of the iodine in the thyroid is to be found in the food and drink. Food from goiterous regions may contain several times as much iodine as that from non-goiterous areas. The relative amounts of iodine available in different localities may be judged from the amount of iodine in the streams. McClendon has been able to trace such a relation between the goiter rate and the amounts of iodine present in water supplies. After analyzing a large number of samples from the whole country and comparing his results with the rate of goiter in men subject to the war draft he concluded that when iodine is present in

water supplies to the extent of 0 to 0.5 part per billion the goiter rate is 15 to 30 per thousand; 0 to 2.0 p.p.b., 5 to 15 per thousand; 2 to 9 p.p.b., 1 to 5 per thousand; 3 to 20 p.p.b., 0 to 1 per thousand. It was the purpose of this investigation to determine the amount of iodine in North Carolina water supplies.

The laboratory method was to add four to five grams sodium carbonate to the 30 to 40 liter sample and evaporate to a moist saline mass. The iodine now mainly in the form of NaI was extracted with hot alcohol. The alcoholic solution was evaporated to dryness and the residue cautiously heated to destroy any organic matter which might have been present. The iodide was now extracted with hot water and the volume adjusted to 15 cc. in a 100 cc. Erlenmeyer flask. Five cc. of a freshly prepared saturated chlorine solution was now added. The solution was boiled vigorously until the volume was reduced to about 10 cc. and no more chlorine could be detected in the vapors. The iodine in the sample is now in the form of iodic acid. A crystal (0.1 to 0.2 grain) of KI was now added. The reaction

$$HIO_3 + 5HI \rightarrow 6I + 3H_2O$$

liberates six times the original amount of iodine present. This iodine was titrated with approximately thousandth normal thiosulfate solution. The amount of iodine found divided by six gives the amount of iodine originally present.

The various reagents were tested to make sure that iodine was not added during the laboratory procedure. The sodium carbonate, alcohol and chlorine water were found free of any detectable iodine. Care was taken to prevent any permanganate being carried over mechanically by the chlorine when preparing the chlorine water. In order to prevent errors due to the decomposition of the dilute sodium thiosulfate this reagent was prepared by diluting, immediately before use, a stock tenth normal thiosulfate solution kept in the dark.

The results of our tests show iodine to be present to the following extent in North Carolina public water supplies:

Wilmington	1.60
Weldon	1.75
Pinehurst	0.67
Wilkesboro	0.63
Raleigh	0.28
Charlotte	0.58
Washington	7.45
Greensboro	1.27

Rocky Mount	2.08
Elizabeth City	1.27
Average	1.73

From these figures there should be more goiter than is observed in the state. To clear up this point we are determining the amount of iodine in various North Carolina soils and the fertilizers used on these soils. In conclusion we wish to express our appreciation for the kind co-operation of the various cities. Their interest in the work made this study possible.

RALEIGH, N. C.

ABNORMAL EMBRYOS OF OATS AND WHEAT

By Lucile Sharpe

Plates 3–6

Our knowledge of polyembryony and false polyembryony among plants is quite limited. Polyembryony is the occurrence of more than one viable embryo in a seed. "The extra embryos may be derived from nucellar tissue, from cells of the integument, from synergids, and in a number of other ways" (3). False polyembryony is the occurrence of a single abnormal embryo with double plumules and primary roots, but with a single cotyledon in a seed (4).

In Kiesselbach's report on "False polyembryony in Maize" there is a short history of the work done on false polyembryony in maize and its relatives. He reviews the work of Shrenk in 1894, of Kempton in 1913, and of Weatherwax in 1921. Weatherwax (7) described two seeds of maize which apparently contained two embryos. But on further investigation and dissection he found that although there were two plumules and two radicles with a duplicated coleoptile and coleorhiza there was only one cotyledon. In 1926 Kiesselbach (4) reported on three similar cases of false polyembryony in corn. Two of these abnormal corn seedlings had two plumules, each with its own coleoptile, and two primary roots enclosed in a single coleorhiza, but with only one cotyledon. The cotyledon from the third abnormal embryo showed two main fibro-vascular bundles while that of a normal embryo showed only one. Miss Anderson (1), in the Department of Agriculture at Washington, D. C., found several true double embryos of *Poa compressa* and *Poa pratensis*. Each of these embryos was complete with its own scutellum, plumule, and root. She found no embryos showing two plumules associated with one radicle or two radicles associated with one plumule.

Another type of abnormality of the corn kernel is that of fasciated embryos. Wolfe (8) and Kiesselbach (5) have described this type of abnormality. The double embryos which arise from fasciated or fused kernels have a very different origin, and therefore will not be discussed.

In the normal embryo of wheat there is a single cotyledon, plumule, and a primary root system of from five to eight roots. During germi-

nation the first portion to emerge from the seed is the coleorhiza. "After the coleorhiza has grown about a millimetre, the enclosed primary root bores through it, usually on one side, leaving a bulging angular portion opposite. An hour or two later the first pair of lateral rootlets becomes visible, each with its thin covering root sheath; these spring from the sides of the short hypocotyl almost in line with the base of the epiblast" (6). Usually in three or four more days, after the three rootlets have grown rapidly, a second pair appears, one on each side of the hypocotyl and immediately above the first pair. Sometimes a sixth rootlet develops later at right angles to the rest of the rootlets and behind the epiblast. A third pair appears immediately above the second pair and in the same plane making in all eight seminal roots (6).

Since no reference to seedling abnormalities of oats was noted in the literature, an effort was made during January to April, 1926, to see if any might be found. Approximately 10,000 kernels of the Fulghum variety were germinated. They were planted in moist dishes, which were 17 cm. in diameter and 7 cm. in depth, and germinated at room temperature. About 150 were planted in each dish. Half were planted on fresh sand and the other half were planted on moist filter paper.

The normal embryo of oats is quite similar to that of wheat.

On March 22, 1926, three abnormal seedlings were found which had two plumules and five roots. Free hand sections, which were made transversely through the embryo of one of these seedlings, showed that there were either two cotyledons fused at their sides or one very abnormal cotyledon with an unnatural shape, which is indicated by a sinus extending partly through the cotyledon region. Plate 3, figures 1 and 2, show two sections through this embryo. On March 29 three abnormal seedlings were found which had two plumules and six roots each. These three seedlings are shown in plate 4. No attempt was made to examine these seedlings microscopically.

Seven abnormal wheat seedlings of the Marquis variety were found by Dr. L. E. Yocum at Ames, Iowa, from among many thousands of wheat seedlings which were germinated in January and February, 1924. They were preserved in formalin, acetic acid, and alcohol preservative until January 1928, when the writer examined and studied them. These seedlings are shown in plate 5. Figure 1 shows a normal wheat seedling with one plumule and five roots. Figures 2, 4 and 8 show abnormal seedlings with two plumules, two separate and distinct coleoptiles, but with normal root systems. The smaller plumule in

figure 2 is seen detached from the larger one and lying to the side of it. Figures 3, 6 and 7 show abnormal seedlings with two plumules, each with its own coleoptile, and normal root systems. The coleoptiles, however, were fused their entire length. Figure 5 shows another abnormal seedling with two plumules, two coleoptiles, and a normal root system; but in this case the coleoptiles were fused only near the hypocotyl region. Plate 3, figure 3, shows a section drawn with a camera lucida through the plumules of this seedling near the hypocotyl. Two vascular bundles can be seen in each coleoptile, which encloses its own plumule. Sections through the embryo in figure 8 show that there were two distinct cotyledons, each with its layer of epithelial cells. These double cotyledons are shown in plate 6 also drawn with a camera lucida. Other sections through the same embryo showed that each cotyledon had its own vascular system. The smaller plumule was found to be associated with the cotyledon to the left while the larger plumule was associated with the cotyledon to the right. The smaller cotyledon came in contact with only a small portion of the endosperm, which might account for its size. No satisfactory results were obtained as to the relation of the roots to the cotyledons, but from an external examination of the seedling it was apparent that there was only one primary root system.

The seedlings which were studied microscopically were sectioned by the paraffin method. The sections were cut 13 to 18 microns thick and stained with Delafield's haematoxylin.

The abnormalities of these oat and wheat seedlings were cases of false polyembryony since two entirely separate embryos were not found in the same seed. All six abnormal oats seedlings had two plumules and a single root system. Five were not examined microscopically for cotyledons but the sixth did show indications of two cotyledons. Of the seven abnormal wheat embryos which were found, three had two plumules and two coleoptiles which were entirely fused, one had two plumules and two coleoptiles which were only slightly fused, and three had two plumules and two separate coleoptiles. The root system was normal in each case. Only one embryo showed two cotyledons. It does not seem possible that these abnormal embryos have arisen from two fertilized eggs or even from a fertilized egg and a synergid cell. Doubtless the embryos in their early stage of development, before the differentiation of their organs, gave rise to two growing points instead of one. This probably accounts for the double cotyledons as well as for the double plumules and coleoptiles. Since the cotyledon is terminal in

monocotyledons (2), a division could occur above the hypophysis which would cause the development of two coleoptiles, plumules and cotyledons without the development of a double root system. In no case was true polyembryony found.

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LITERATURE CITED

(1) ANDERSON. Development of the Female Gametophyte and Caryopsis of *Poa pratensis* and *Poa compressa*. Journ. Agric. Res. **34**: 1001–1018. 1927.
(2) GOEBEL. Outlines of Classification and Special Morphology, 393–402. 1887.
(3) HOLMAN AND ROBBINS. A Textbook of General Botany, 545. 1924.
(4) KIESSELBACH. False Polyembryony in Maize. Amer. Journ. Bot. **13**: 33–34. 1926.
(5) KIESSELBACH. Fasciated Kernels, Reversed Kernels, and Related Abnormalities in Maize. Amer. Journ. Bot. **13**: 35–39. 1926.
(6) PERCIVAL. The Wheat Plant, 24–33. 1922.
(7) WEATHERWAX. Anomalies in Maize and its Relatives. Bull. Torr. Bot. Club **48**: 253–255. 1921.
(8) WOLFE. Fasciation in Maize Kernels. Amer. Nat. **50**: 306–309. 1916.

EXPLANATIONS OF PLATES 3 AND 6

PLATE 3

Fig. 1. Cross sections of an abnormal oats embryo showing two cotyledons. ×33. *A*, *B*, *C*, *D*, *E*, roots; *F*, *G*, cotyledons; *H*, *I*, endosperm.

Fig. 2. Same as above. ×33. *A*, plumule; *B*, *C*, cotyledons; *D*, *E*, endosperm.

Fig. 3. Section through abnormal wheat seedling showing two plumules and two coleoptiles. ×73. *A*, *B*, coleoptiles; *C*, *D*, plumules; *E*, *F*, *G*, *H*, vascular bundles; *I*, line of fusion of coleoptiles.

PLATE 6

Section of abnormal wheat seedling showing two cotyledons. ×73. *A*, plumule; *B*, normal cotyledon; *C*, abnormal cotyledon; *D*, *E*, remains of endosperm; *F*, *G*, *H*, roots.

PLATE 3

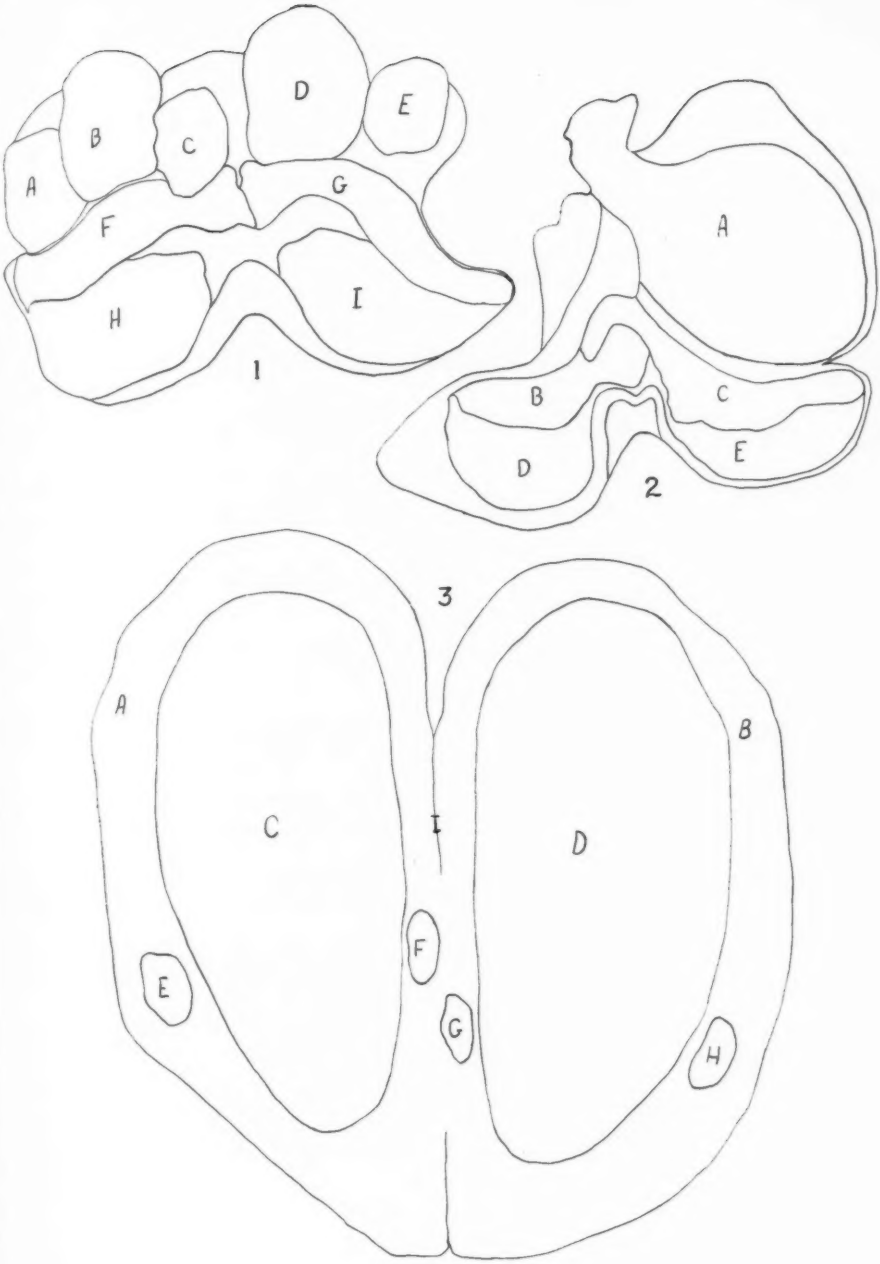

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PLATE 4

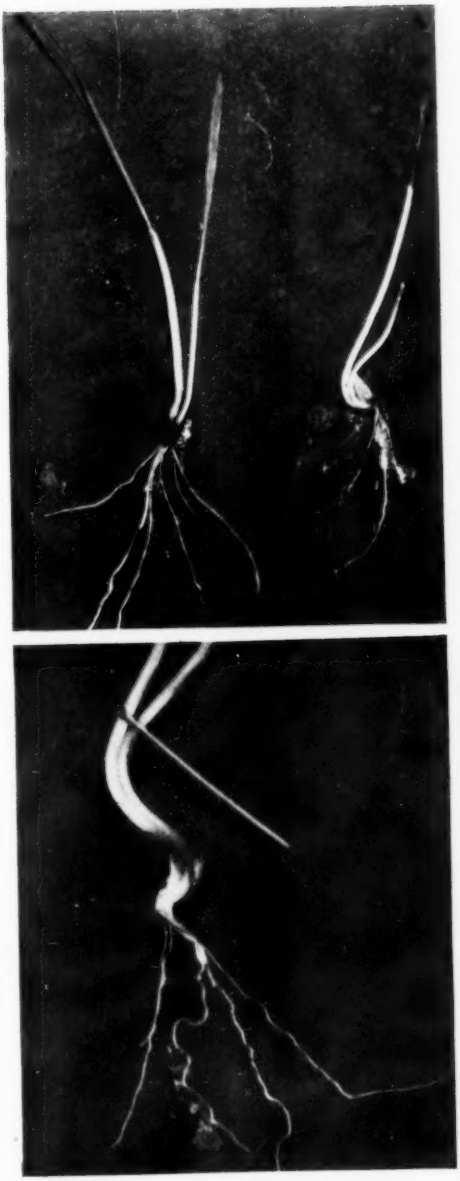

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PLATE 5

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PLATE 6

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FLORA OF THE TRYON REGION OF NORTH AND SOUTH CAROLINA

AN ANNOTATED LIST OF THE PLANTS GROWING SPONTANEOUSLY IN POLK COUNTY, NORTH CAROLINA, AND ADJACENT PARTS OF SOUTH CAROLINA, IN GREENVILLE AND SPARTANBURG COUNTIES

PART I. INTRODUCTION: SOILS, CLIMATE, ETC., FERNS AND CONIFERS (PTERIDOPHYTA, GYMNOSPERMAE)

By DONALD CULROSS PEATTIE

INTRODUCTION

The "Tryon region" is a phrase that to those who know it constitutes a fairly clear designation of a fine area of mountains, hills, uplands, and forests, yet it has actually no very sharp definition. Thus the area that is to be considered in the following pages includes not only the whole of Polk County, but even transcends the state line and includes a small portion of South Carolina, namely Glassy township in Greenville County, and Landrum township in Spartanburg County, for the reason that from a botanical point of view, as well as from the point of view of residents in this general neighborhood, these portions of South Carolina are integral with the "Tryon region." Primarily, however, this is a flora of Polk County, North Carolina.

Polk County is among the smallest in the state, and lies partly in the Blue Ridge, partly in the piedmont. It is a somewhat obscure neighbor of far more famous regions, such as Chimney Rock on the north, Caesar's Head on the southwest, Flatrock and Hendersonville on the west, and compared with these it has been and still is botanically little known. It is not a rich or populous county, nor highly developed agriculturally. Its forests are not of sufficient importance to have been lumbered, and hence they are actually in better condition than the forests of many other parts of the state originally more famous for their trees. By escaping fame and development this little county has preserved its wildness and beauty and, from a scientific point of view it is botanically of great interest for these very reasons.

These papers upon the flora of the Tryon region are to comprise an annotated list of all the flowering plants and ferns within the area, so

far as the present writer knows them, with citations of specimens. Perhaps at a later date it may be possible to do the same for the more primitive plants. It is not, however, to be assumed that the present catalogue is complete. Although the accessible parts of the county have been rather intensively explored, and the spring flora is very well known, the more distant mountains, the less attractive, rolling, eastern parts of the county, and many river courses have not been botanically traversed, and in the summer and autumn flora much yet remains to be done.

The nomenclature of this work endeavors to follow the so-called International Code. The synonymy, while not complete, is intended to give the names used by the followers of the so-called American Code, particularly those found in Small's "Flora of the Southeastern States," and to provide the student, also, with the original Linnaean name, and all those synonyms by early writers on the flora of the Atlantic states, such as Elliott, Chapman, Pursh, Nuttall, Rafinesque, Walter, Marshall, etc.

The present writer is happy to acknowledge the assistance of the following persons who have identified specimens for him in their technical specialties: Dr. Francis Pennell; Dr. John K. Small; Mrs. Agnes Chase; Dr. William Maxon; Prof. M. L. Fernald; Dr. Edgar T. Wherry; the late Dr. Ezra Brainerd; Dr. Karl Wiegand; Mr. Charles Weatherby. He is profoundly indebted, also, to the following persons who have collected plants for him in and around Tryon, or loaned him their collections for verification: The Hon. Joseph Richmond Churchill; Mrs. Gertrude Ludlom; Miss May E. Day; Miss N. L. Kimber; Mr. E. C. Townsend, and my parents, Mr. and Mrs. Robert B. Peattie. Mr. Francis MacBride of the Field Museum has kindly assisted me in connection with Polk County specimens in Chicago.

As a preface to the following notes it should be stated that they are by no means an attempt at a true ecological introduction to the vegetation of the region, nor can an extensive philosophical view of the origin and the affinities of the flora be attempted here. These matters deserve an amount of special study that cannot now be contemplated. For these reasons the paragraphs on soil, climate, etc., can only be taken as suggestive preludes to the study of the vegetation.

HISTORY OF BOTANICAL EXPLORATION

Polk County and the adjacent townships in South Carolina seem to have escaped botanical exploration by all the early botanists who

traversed the Southern Appalachians. It was not known to Michaux, Lyon, Bartram, Fraser, Catesby, nor to the comparatively recent collectors such as Sargent, Gray, Sullivant, and Small.

In "The Correspondence of Linnaeus," vol. 1, p. 374, there is a letter from Alexander Garden of Charleston, in which he mentions his journey to "Saluda" in 1755, in company with Governor Glen who went to conclude a treaty with the Cherokees. It would be interesting if one could prove that this eminent botanist actually visited the region under consideration, but the term Saluda was then extended to include a very large tract of Blue Ridge territory, and it seems more likely that Glen, and with him Garden, reached the foot of the mountains somewhere near Caesar's Head.

Again, in his "Sketch of the Botany of South Carolina and Georgia," Stephen Elliott writes a dedication to Dr. James MacBride, a physician who explored botanically the headwaters of the Saluda River. As the Saluda River has an east fork (the one included in our area) and a west fork, in the neighborhood of Caesar's Head, it cannot be demonstrated that Dr. MacBride actually entered our area. Of the twenty-eight plants listed by Elliott as found around the headwaters of the Saluda by MacBride, eighteen are found in our area. This however proves nothing definite. It has not been possible to establish the date of his visit to the mountains, but it seems likely that it occurred about 1800.

In Ramsay's "History of South Carolina," vol. 2, pp. 161–2, occurs a note on Glassy and Hogback Mountains, containing the first printed reference to the plants of our area. This quaint paragraph is full of misconceptions about the mighty caverns, terrific blizzards, and immunity from lightning which these mountains are supposed to enjoy. There is some hint however of the importance of the thermal belt on the southern slopes, and farms, peach orchards, and apple orchards are noted. The abundant chestnut trees and "wild pea vines" are the only native plants mentioned. This volume was printed in 1858; the author of these observations is not stated by Ramsay.

The first true record of botanical exploration of Polk County is found in *Garden and Forest*, vol. 4, p. 86, in a brief sketch of winter botanizing around Lynn in 1891, by the late Frederick H. Horsford, nurseryman, of Charlotte, Vt. Little is noted except some evergreen ferns; he apparently made no specimens, at least none are known to his friends and family.

Probably about 1895 the late Dr. Arthur Middleton Huger of Charleston, S. C., visited Tryon and collected a few plants, notably some Trilliums of particular interest.

From private correspondence with Mr. William Willard Ashe of the Forest Service, U. S. Department of Agriculture, I learn that he visited Polk County in 1895, collecting unusual species of *Tilia* in the Pacolet gorge. He was present on the same ground in 1916 securing some new rhododendrons. His specimens are found to some extent in the National Herbarium, but for the most part they are in the herbarium of the Forest Service, and scattered and inaccessible. He has kindly furnished me with a list of his collections, as he remembers them.

In 1897 and for four or five years subsequently the Biltmore Herbarium sent several botanists into the county, among them Mr. C. W. Beadle and Mr. Frank Boynton. Most of their work seems to have been done on White Oak Mt. Unfortunately flood destroyed that herbarium, but Polk County specimens from the collection are found in many other herbaria. These are still coming to light, but there is no way to trace them all down.

The year 1897 was further remarkable for the advent of Mr. Edward C. Townsend, then of Cornell University, now of Olympia, Washington, who settled in Columbus in January of that year and remained until December 1903. During his first four years especially he botanized extensively, amassing what must have been the largest and most interesting collection of plants ever taken in the county. Unfortunately his specimens have been divided among various institutions and often merged without record among their herbaria. I have examined all his specimens in the National Herbarium at Washington, and most of those in Mr. Townsend's own private collection, courteously forwarded to me. His non-duplicated types and the bulk of his collection are in the herbarium of Cornell University, and some of his non-duplicated specimens have been verified for me by the kindness of Dr. Wiegand.

The Honorable Joseph Richmond Churchill of Dorchester, Mass., visited Tryon in May 1899 and made a small but excellent collection. His specimens are in the Gray Herbarium and his private collection. I have been privileged to view many of them.

It is appropriate to speak now of the work of some resident amateurs. Early in the nineties of the last century there came to Polk County three persons interested in its plant life. It seems certain that, from about 1900 on, all were interested in local botanical investigations.

Samuel Greene, a naturalist and educator, retired to Tryon in his old age. He was the type of the old fashioned all-around naturalist, interested in mineralogy, conchology, algology, and horticulture. He amassed a collection of local minerals and of polished specimens of woods

from timber trees of the region, and a series of leaf specimens of local trees and shrubs mounted under glass. Before his death in 1910 his mind wandered, and to this cause may be laid some strange inclusions in his collection. Several of his specimens are great rarities, but probably authentic. In 1919 I found his collection moulding in the basement of the library, much of it hopelessly damaged. It is now in the public school.

Miss Frances Wright, a nature lover who died in 1905, was one of the amateur botanists. She left no herbarium, but noted down in her copies of ed. 1 of Britton and Brown's "Illustrated Flora" the plants she had found. Her copies of this book are in the library, and in some sense they constitute a list of Tryon plants. The book however was not suited to the locality, nor does the present writer feel that her determinations can be accepted without reserve. The same method of notation was used by Miss Margaret Morley, who lived in Tryon until 1920. Her copies of Britton and Brown are in my possession.

From 1914 till his death in 1924 Mr. George Woolson, a retired nurseryman of New Jersey, lived in Polk County. He occasionally furnished me with botanical notes on plants seen, but these were unsupported by specimens.

A brief visit was paid to Polk County by Mr. T. G. Harbison of Highlands, N. C., in 1916. He took some rare Tilias and Trilliums.

From the late autumn of 1910 to May 1911 and again from November, 1918 to May 1919, and in the winter and spring of 1928, Miss May E. Day of Oberlin, Ohio, visited Tryon and made a representative collection of plants. I have had the pleasure of examining all her specimens, which are chiefly in her private herbarium.

Dr. Frederick Millspaugh of the Field Museum, Chicago, visited Tryon in May 1918 and made a moderately large collection which I have examined in detail.

In the spring of 1919, the winter of 1920, the summer and autumn of 1921, and the springs of 1922, 1923 and 1926, the present writer was in residence and made extensive collections which are deposited in the Gray Herbarium, the herbarium of the University of North Carolina, and elsewhere. In the autumn of 1926 and summer of 1928 my parents collected for me a group of late autumn-flowering plants.

Dr. Edgar T. Wherry visited Polk County for three days at the end of May 1928 entering the county from the northeast, from the direction of Rutherfordton, and visiting Hogback Mt., Pearson's Falls, and the neighborhood of Tryon. He left by the north, going to Chim-

ney Rock. He revisited Hogback in September of the same year, in company with Dr. Francis Pennell of the Philadelphia Academy of Sciences, specialist on the Scrophulariaceae.

In the spring of 1928 Miss N. B. Kimber of Philadelphia, Pa., collected plants in and around Tryon, courteously forwarding her collections to me.

TOPOGRAPHY AND PHYSIOGRAPHY

From a botanical point of view the topography and physiography of the area are of the utmost importance. In the opinion of the present writer they exceed in botanical significance both the climate and the nature of the soil, as regards the local distribution of plants, though not in respect to the composition of the flora as a whole, where geology and meteorology are more important factors.

There are two main features of the topography of the area under consideration, namely the piedmont which predominates in the east, a high, rolling area much dissected by streams having narrow bottomlands or floodplains, and the Blue Ridge, a chain of mountains rising as the front wall of the Appalachian system. The mountains have this peculiarity that while they appear as mountains, and are mountains, when seen from the east, their low, rounded summits merge on the west into the Asheville-Hendersonville plateau. An exception to this statement is seen in the Tryon Range, which, broadly considered, includes the two Warriors, Tryon Peak, and White Oak Mt. These mountains are thrust out as an arm of the Blue Ridge in a northeasterly trend, into the piedmont.

The lowest land in the area is that at Poor's Ford in the extreme southeastern portion of Polk County, which is approximately only 800 feet above sea level. The highest peak is Wildcat Spur, only 3,239 feet in altitude. The prevailing altitude of the piedmont country as a whole is in the neighborhood of 1,000 feet. While seven mountain peaks are over three thousand feet, the great mass of mountain land does not lie so high, but rather between 1,500 feet and 2,500 feet in altitude.

Botanically interpreted, the significance of these facts is as follows: There is very little level land, and consequently there are no lakes, swamps or bogs, except of extremely small extent, or of an artificial nature. All water is swift-moving water and in the mountains predominantly of a cascade type. There are no mountains of sufficient height to make any really important differences, by pure virtue of altitude, in the climate, although the difference in the oncoming of spring

and autumn is as much as two weeks between highland and lowland. However, it is true that the mountains support a flora of northern affinities, the piedmont a flora of southern affinities, but this is not due to altitude, but rather to angle and direction of slope.

Thus, a very steep mountain hillside is certain to be left under forest cover, and where the forests survive they will provide a humus, a protection from transpiration and heat and run-off and erosion, that enables the typical Alleghenian plants to survive. Further, the northward slopes of mountains, or even the northward slopes of glens anywhere in the mountains, remain in shadow a sufficient part of the day even in summer to have temperatures distinctly lower than the sunny southerly and easterly exposures. These differences are easily perceptible to the human skin in passing from one side of a glen to another, and the difference in the flora too is by no means inconsiderable.

In this fashion the montane or Alleghenian flora may extend out on the piedmont in certain cool rich glens, and the typical Carolinian flora of the piedmont is by no means uncommon on warm mountain slopes, especially in the thermal belt, of which more shall be said elsewhere, and on the domes of the mountains. Thus the flora of Tryon Peak, one of the highest points of land in the county, is more characteristic of the piedmont vegetation than the Alleghenian flora of such a cool rocky gorge as "Glen Walden" within the corporate limits of the town of Tryon, at only 1,000 feet altitude.

The chief factor in determining the present character of the piedmont flora is Man. Lands suitable to agriculture, lands formerly farmed and now abandoned, lands logged over or burned over, suffer changes in their flora, and those plants are in the majority on the piedmont which can adapt themselves to the changing adjustments of human life. Here occur such introduced weeds as there are (and their number is very small in this flora), and such trees as make quick growth in soil not the richest. Compositae, Leguminosae, and such summer plants are the characteristic herbaceous flowers of the piedmont, whilst the Alleghenian forests of the mountain region support what is dominantly a spring flora, scattered through a large number of families having each, with us, but a few representatives, except that the Liliaceae and Ranunculaceae dominate.

The topography of the area, with its steep gradients, accounts for the almost complete lack of aquatic life, except for a very specialized type, the grotto-like formations of dripping rocks in cool mountain forests and cliffs.

ROCKS AND SOILS

So far as is known to the present writer no systematic or complete study of the rocks and soils of Polk County has been made either by the state of North Carolina or by the federal geologists. Fortunately the western neighboring county, Henderson, has been geologically mapped, and both it and the two neighboring counties in South Carolina, Spartanburg and Greenville, have been mapped for soils. (Cf. "Soil Survey of Greenville Co., S. C.," by Watkins, Snyder and Smith, Bureau of Soils, U. S. Dept. Agr., 1924; "Soil Survey of Spartanburg Co., S. C.," by Latimer, Deeter, Perkins, Hearn and Van Duyne, loc. cit., 1924; and "Soil Survey of Henderson Co., N. C.," by Hearn and Macnider, loc. cit., 1908.) These publications have furnished the basis of the present writer's soil observations in Polk Co., which obviously partakes of the soils of its mountainous neighbor county on the west, and its piedmont neighbor counties on the south. Although these observations are therefore not the work of a professional geologist or soil expert, they will, it is hoped, serve as a basis not too insecure when assigning plants to their soil habitats. The present writer has confined his attention to the predominant types of soil, such as one may recognize with some certainty. There are doubtless many smaller and scattered areas of soil types other than those here mentioned, such as Appling sandy loam, which are not common enough to be of importance to botanists.

The rocks which have formed the soils of Polk County belong to that very ancient backbone of granites and gneisses of which the Blue Ridge and its adjacent piedmont are formed. The botanist speaks of these rocks as "acid," from the reactions of the resultant soils and waters. The dominant rock is the very old and fine-grained Whiteside granite, a rock that is often spoken of as "rotten" owing to its almost soil-like nature in many of its outcrops. It is composed of orthoclase and plagioclase feldspars, quartz, biotite, and muscovite. In many places in the mountains outcrops of the light-colored rock are seen, as well as of the darker Henderson granite which contains large crystals of porphyritic orthoclase feldspar. Hornblende schists are common in the mountain rocks.

The rocks that underly the piedmont clays frequently outcrop, but for the most part these Carolina gneisses are rather deep-buried. They are rich in quartz-mica schists.

The above account is certainly far from adequate, but more cannot be ventured by one with so slight a knowledge of geology. It has been somewhat easier to identify the chief soil types of the county. All the

soils, except those in bottom lands are residual. The three chief type series are the Porter, Cecil, and Congaree soils.

On the flat or rolling tops of some of the highest mountains, such as Hogback, Rocky Spur, and Whiteoak Mountains is found a soil called Ashe loam. This is but slightly different from the loams of the Porter series except that it is derived from the least weathered of the mountain granites and gneisses. It has a surface of yellowish brown to grayish brown heavy sandy loam about 6–10 inches deep, with many mountain boulders intermixed with it. The subsoil is a friable clay loam, yellow to light buff, with many mica flakes; usually the bedrock is close to the surface. This soil, to judge from its plants, is what is loosely termed a "sweet" soil, that is it approaches neutrality in the hydrogen ion scale, and supports a growth of herbaceous types loving rich loam. The forest cover is dominantly of hardwoods of the Alleghenian type.

Turning now to the vastly more important Porter series of soils, we find them chiefly on the mountains, the spurs running out from the mountains, and on the isolated ridges out on the piedmont that rise especially high. Where there has never been tillage the upper layers of the Porter soils display an inch or two of brown loam highly charged with organic matter. Beneath this is a yellowish brown loam of granular form, while the typical subsoil is a friable reddish brown clay loam. These soils are derived from granite and gneiss, but have not been so deeply weathered as the Cecil soils, and bedrock is seldom more than three feet below the surface. Roughly speaking the surfaces of the Porter soils, from which layer the herbaceous plants derive their nourishment, are "sweet," approaching neutrality between acid and base, though slightly on the acid side.

Four types of Porter soils have been observed. Porter loam has a dark brown surface, blackish under forests, grayish under thin plant cover, or even sandy near rock outcrops, which is soft and mellow. The subsoil is a reddish brown or red to yellowish brown with much loose micaceous schist. It is derived from the Whiteside granites that have been deeply weathered and long forested, and inclines toward neutrality, is rich in plant species, both herbaceous and woody, of the Appalachian types, and is dominated by oaks, chestnuts, hickories, or, in cool steep mountain glens, hemlocks. The mountain birch, and sometimes especially where the ground is more level, the white pine are found in this soil.

Porter stony loam is merely a phase of the foregoing, abundant on steep mountain walls and highly admixed with boulders. Because so

unsuitable to agriculture it is especially heavily wooded. Porter sandy loam has a yellowish gray to gray, medium to coarse, sandy, loamy surface 6–15 inches deep, darker under heavy forests, lighter and reddish where eroded. It grades into Porter loam in the western part of the county, and is loose, friable, mellow, and contains scattered quartz gravel and mica. The subsoil is a sticky, heavy sandy loam or clay, of a reddish or yellowish brown. This soil occurs on mountain areas, especially in the northwest corner of the county, on steep mountain sides and plateaus. The Whiteside granites are its source, and, besides oak, chestnut, or occasional pine, the laurel and rhododendron are its most conspicuous plant covers.

Derived from the disintegrating granite is the Porter sand, which has a shallow surface of a yellowish gray or gray, medium to coarse or light sandy loam, often with 10–15 per cent of fine rock fragments and small granite boulders intermixed. The gradation to the yellowish to brownish sandy loam or sticky sandy subsoil is imperceptible, as is the gradation from subsoil to rotten rock. This type of soil occurs chiefly on mountain tops where the soil is thin and "poor" and on the leached and sandy flat crests of spurs of the mountains and long high ridges on the piedmont. This is what is popularly termed a "poor" soil; it supports a growth of laurel, *Epigaea*, *Gaylussacia*, and other ericaceous plants preferring an acid soil and, on some mountain ridges, the Carolina hemlock (*Tsuga caroliniana*), in company with *Rhododendron carolinianum*, grows upon this soil.

The soils of the Cecil series dominate the piedmont and by their reddish color give to the piedmont its famous name of "red hill country." The types differ chiefly in the variations of the color, structure, and texture of the surface; the subsoil which grades into the surface soils, is pretty largely the same throughout—a red, firm, brittle clay, with an admixture of sharp quartz sand and quartz veins and minute mica scales. Where erosion has occurred the subsoil is laid bare in bright-colored gullies and these are generally without vegetation. By no means deficient in plant foods, they none the less give an acid reaction, excluding the herbaceous types of the Porter loams, and they are poor in humus except for a thin layer found especially under heavy hardwood forests.

On the uneroded flat tops of piedmont ridges, and on rolling plains occurs a highly absorbent well drained type called Cecil sandy loam, with a thin dark yellowish brown mellow organic surface underlain by a yellow sandy subsurface. The bedrock is usually deeply buried under

this soil which is largely cleared for agricultural purposes, but in places supports a pine and hardwood growth of Carolinian forest types.

Very similar is the Cecil sandy clay loam, but more sandy and with a considerable amount of mica in the surface soil where it occurs near the mountains. It is largely exploited for agriculture, and its plant cover is chiefly second growth, in old fields, of loblolly pine in the eastern part of the county, *Pinus echinata* in the western part.

The typical Cecil clay loam occurs less commonly, in detached areas and chiefly on low hills, along stream bottoms and lowlands. It has a very thin surface darkened by organic matter below which it merges through a dark brown mellow loam to the subsoil of friable red clay which is plastic when wet, and friable when dry, but becomes compact at depths. Here occurs an admixture of angular quartz grains and finely divided mica and not infrequently concretions of iron. Largely exploited for agriculture, its plant cover is chiefly second growth of pine.

This brief soil study has now descended to the bottom lands of the county, and here are encountered the first alluvial soils, the Congaree materials. The Congaree fine sandy loam has a grayish brown to light brown mellow surface often with a micaceous schist admixture. The subsoil is light brown to brownish yellow, a fine, sandy, micaceous loam. Such soils occur in the narrow, winding little bottom lands of creeks where they wind up into the mountains and foothills. Cultivation has generally been practised at some time on these small bottomlands, and the vegetation is hence seldom virgin. The cane (*Arundinaria tecta*), willow (*Salix nigra*), the plum (*Prunus angustifolia*), and species of *Panicum* and *Andropogon* are frequent in such spots. There are often, just where the streams from the mountains strike more level ground and, losing their velocity, drop their heavier content, small outwashes of sand and gravel overlaid upon such spots.

The Congaree silt loam occurs in the bottomlands of the larger streams and rivers and is accounted first-bottom overflow land. The surface is dark reddish brown, mellow in forested areas, lighter in cultivated areas, and this grades into the subsoil which is a brown silt loam to silty clay loam, more compact and paler than the surface soil. Here grow such riverbank trees as *Betula nigra, Nyssa sylvatica, Acer Negundo, Fraxinus biltmoreana, Alnus rugosa, Viburnum prunifolium, Platanus occidentalis* and *Salix nigra.*

The last classification of soils is one generally accounted miscellaneous, the meadow soils of Congaree material. The word meadow as used in the Government soil surveys does not necessarily coincide with

the ordinary definitions of the term, but applies to a dark, poorly drained, mucky soil of alluvial grounds, in the case of Polk County confined to the overflow and terraced lowlands of the lower courses of the Pacolet and Green Rivers. Its surface is brown to reddish brown, its subsoil slightly lighter, often mottled with rusty or drab colors. Pure sand and gravel beds are often superimposed upon such lands. These soils, of course, are derived from the Cecil soils of the uplands, and from the Porter soils of the mountains. The plant cover is generally alder, willow, sycamore, red birch, Virginia or scrub pine, rushes and sedges.

Such are the chief types of soils, considered from a geological point of view. The botanist views soils in a manner slightly different. It is beyond doubt that the territorial and local distribution of plant species is profoundly affected by soils, and soils in this matter function both in a chemical and in a mechanical way. Mechanically the variability of soils in relation to the plants they support, is largely a matter of moisture content. Thus the geologist refers to the Porter soils of the mountains as well drained soils. However the very considerable humus of the Porter loams, and the shade cast by the forests these soils support, make the top six inches of such soils rather constantly damp, if such a vague word may be allowed, and in this way the herbaceous plants of the Porter soils on the mountains are plants demanding a considerable moisture content in the soil. The Cecil clays, on the other hand, which are reckoned as less well drained by the geologist, are so poor in humus and so thinly shaded that for the purpose of most herbaceous plants, these soils are actually more subject to drought-like effects, even in short dry spells, than the plants of "well drained" Porter soils. Also the plants growing on the ordinary red clay bank are more exposed to transpiration loss than those of the Porter soils.

The apparent separation of mountain species from piedmont species or, in other words, of Alleghenian and Canadian types from Carolinian and coastal plain types, is due in many cases not at all to altitudinal differences, for the altitudes of this area are botanically speaking of slight importance, but to the differing moisture content of the mountain soils and the piedmont soils. The mountain soils are chiefly damper, hence cooler.

The chemical differences in soils as a factor in plant distribution is well known. The soils of this area are all upon the acid side of the scale used by Dr. Edgar T. Wherry, which is as follows for our area:

Low minimacid—active acidity 0.5 to 2.00; pH 6.9 to 6.55.
High minimacid—active acidity 3 to 8; pH 6.5 to 6.1.

Low subacid—active acidity 10 to 30; pH 6.0 to 5.55.
High subacid—active acidity 31.5 to 80; pH 5.5 to 5.1.

Mediacid—active acidity in hundreds; pH 4.1 to 5.0.

Dr. Wherry very kindly made some soil tests for the present writer when in Polk County, and obtained the following results which, though they cannot be correlated absolutely with the soil types referred to above, are at least suggestive.

Red clay, throughout county; chiefly low minimacid, occasionally low subacid.
Soil under pines, chiefly *Pinus echinata;* subacid.
Soil under *Kalmia latifolia* in woods around Tryon: mediacid.
Soil in woods along Vaughan's Creek, high minimacid.

The above were obviously largely tests made in Cecil soils or the more "sterile" of Porter soils as they occur in the piedmont. Following are some tests made upon soils at Pearson's Falls, which would be exclusively Porter soils of the mountains.

Soil of the upper forested slopes: low subacid.
Soil of much of the ravine slopes: low minimacid.
Soil of "The Grotto" (aside from the water): high minimacid

The following water tests were made:

Water of Pacolet River: low minimacid
Water of the brook at Pearson's Falls: low minimacid
Water of the grotto, with algae in it: high minimacid (probably owing to the presence of CO_2)

Thus the most acid soils that Dr. Wherry tested was that found under laurel; it is notorious that ericaceous shrubs prefer acid soils, whilst the "sweetest" or least acid soils were those of the mountain forest loams, the habitat of certain Saxifragaceae and other plants that shun the strongly acid soils.

The data of Dr. Wherry's soil tests and what they suggest about the soils of the region in general, have significant botanical bearings. The inclination of the soils toward acidity accounts for the development of such families as the Ericaceae. Although not the most numerous family, either in number of species or number of individuals, the heath family or rhododendron family as it might here be called, is certainly the conspicuous family of the region. The soils approaching to neutrality are conspicuous for their Saxifragaceae, Cruciferae, Rosaceae, Liliaceae, etc.

There are no actual data on the amount of available nitrogen in the soils of this area, though it is safe to state that the Porter soils are rich in it, the Cecil soils poor. None of the soils apparently are so devoid of it as to encourage the growth of such a plant as *Myrica aspenifolia*, which is found chiefly upon soils with a poor nitrogen content, and is quite absent from our flora.

TEMPERATURE AND RAINFALL

The climate of Polk County is variable over its several parts, and precise data are available only for a fifteen year period at Tryon. Tryon itself may be taken as fairly representative of the region where the population is thickest, and its climate is therefore of great human importance. However this does not assist the botanist materially in the matter of climate in the mountains, nor out on the piedmont. A few observations of an official nature are available for the summit of Warrior Mt., not however, a particularly high or significant peak, as it is exposed in such a way as to have, roughly, a climate not entirely dissimilar to that of the piedmont, at least as regards temperatures.

Anyone who has ever gone, on a blistering summer day, from Tryon to Pearson's Falls, and stepped into the deep shadowed glen, down which washes an eternal breeze set in motion by the waterfall and flecked day and night with the spray from the cascade, has known, as he sat down in the deep shade of that beautiful spot, that he has entered another climate. He sees there, in July, violets still in bloom, and all is still green and fresh, no matter how sear the lowland woods may be. The plants, too, are reacting as to a different climate. But in what way different and how different there are no official statistics.

The whole mountain region, and its interior lowland valleys, is therefore a patchwork of special climates, each one of which might profit by study. Undoubtedly the individual conditions in the mountains exert an influence on the distribution of the plants, as well as do soil, surface and ground waters, angle, exposure, and altitude. But it is impossible here to express those differences in any defined fashion.

The eastern part of the county has, it is inferred, distinctly less rainfall than the western. Lines drawn through points in North and South Carolina having the same mean average, pass through Polk County, according to the Government's official maps, although I do not believe the rainfall of the eastern part of the county is known otherwise than by logical inference. Indeed, Polk County, for its size, presents almost the widest rainfall gradient in the state, having a probable mean average

rainfall of fifty-four inches in the extreme eastern piedmont part of the county, whilst in the mountainous western portion it has a probable mean average of seventy inches. The town of Tryon has a definitely known mean average of sixty-one inches.

Thus it can be stated with some authority that the mountainous western portion is cooler and rainy, heavily rainy, indeed; the low, sandy-clay eastern parts of the county are warmer and drier. But only for the foothill region around Tryon are there any definite figures.

The town of Tryon, with its weather recording instruments located at 1,075 feet above sea level, has a mean average precipitation of five and six-tenths inches for January, decreasing steadily to four and thirty-eight hundredths in April. May, however, averages five and twenty-one hundredths; June is not quite five inches, July (the thunderstorm month) is almost eight inches, but August is scarcely more than five inches, and from then until November rainfall declines steadily till in the latter month it is just over three inches. In December it rises again to five and forty-six hundredths inches.

Interpreted in terms of seasons this means that the winters are relatively rainy—the rain being distributed rather evenly from December to March. It might be added here that the slight snowfall is as follows: 3.4 inches in December, mean average; seven inches in January, and 2.8 in February. Snow seldom lingers many hours except on the highest mountains. January is therefore the most "adverse" month from both the human and botanical standpoint. Spring is actually underway, measured in terms of the first blooming of native plants, early in February, but for practical purposes spring, as a popularly understood season, begins in March.

In March and April the winter rains cease; there is always some rain in these months, in the form of light warm showers. May is rainier.

Summer begins with June, a month not particularly given to rain except in thundershowers. July is the regular thunderstorm month, and has the highest precipitation of all August shows the same type of rainfall, but lessened in amount, and the signs of the autumn dry spell are usually visible in August.

The autumn months average very little rain, relatively speaking. It is now that the woods take on a somewhat sear appearance, and forest fires are to be dreaded.

Botanically interpreted these facts mean that there is available plenty of moisture for the encouragement of an early and abundant spring. The summers too have sufficient moisture for the purposes of vegetation,

constant greenery and abundant blooming. The autumns incline toward the dry, and vegetation is subject to severe loss by transpiration; flowering is not abundant, but autumn coloration is high.

The temperatures, if they were taken from enough places, might have some botanical significance. As it is, the average means, as well as the absolute maximums and minimums, have little importance in this study, though of course in relation to horticulture these are vitally significant. The mean winter temperatures range between forty-one and forty-four; the mean spring temperatures are from above fifty-one degrees Fahrenheit in March to more than sixty-five in May. June has almost seventy-five degrees of average temperature; July is a little hotter; August is about the same as June. September is still quite warm, with over seventy-one degrees. By November the average is as low as fifty-one. The average annual temperature is fifty-nine and six tenths degrees, but this sort of average has no meaning either from a botanical or a human standpoint. The maximum temperatures also are quite devoid of significance in this study. The absolute minimum seems to be three degrees below zero, but this also has no significance for wild plants such as it has for cultivated ones.

Summarized, the winters are cool, often hovering near or going below the frost point, at least at night, and while often clear and balmy have a considerable rainfall evenly distributed. The springs are a little less rainy, and are steadily warm, the last frosts of importance seldom occurring after the middle of April. From a botanical, as from a human standpoint, spring is the delightful time of year. The summers are hot, highly variable in their amount of precipitation, some years being excessively rainy, some excessively dry, but usually fairly rainy. The autumns are dry, balmy, and not given to early frosts, and rival the spring in pleasant sensible temperatures.

It should be repeated that all these figures pertain to the town of Tryon, according to the summary of the climate of West Central North Carolina (Section 89) by the United States Weather Bureau. There are also contained therein some figures for Lynn, but these are too scanty to mean anything. But in Supplement 19 of the *Monthly Weather Review*, 1923, occurs an article entitled "Thermal Belts and Fruit Growing in North Carolina," by Henry J. Cox, which has important climatological statistics on another portion of the county.

It is not denying the possible significance of the thermal belt in the native vegetation, to say that it means more to the fruit raiser than to the botanist. In my observation the thermal belt, despite the rarity

of frost within its bounds, and its constant temperatures, has no plants peculiar to itself, nor any that are not found equally in other parts of the county. The fine shades of difference in temperature in the thermal belt are of the utmost significance to sensitive cultivated plants, but I have been unable as yet to discover that the thermal belt has any more importance to the native vegetation than that this area, being valuable for farming, is generally completely stripped of its native plants.

Climatological figures are ordinarily used to interpret the vegetation. This method is wholly empyrical, and except when large continental masses are considered, it has very little significance to the botanist as regards the reasons why plants occur where they do, or fail to occur. Thus it is plain that climate, among other things, explains why the tip of Florida has West Indian plants, and why the summit of Mt. Washington has Arctic plants. But climate cannot explain why plants grow at one spot in a county, and do not grow half a mile away. However, the figures of meteorology are not useless to the botanist even in the study of a small region. One of the things that the botanist can do for science is to tell the climatologist, by means of the vegetation, what sort of a climate he has—in other words to reverse the usual deductive process of thinking, and speak inductively of the climate, drawing his conclusions about it from the nature of its vegetation.

Tell a botanist that a region has numerous epiphytes, or tree-perching plants, and he can tell you something about the climate, namely that it must have very heavy rainfall, low wind velocity, and high humidity. Tell him that the region excels in bulbous plants that make an early and abundant blooming, and then completely disappear from above ground, and he can tell you that the climate is dominantly arid and warm, and that the summer season is the adverse or dormant season, the spring the balmy season.

Viewed as a cause, the climate of Tryon, judged from its effect (its vegetation) is one fitted to support the growth of rather heavy forests, and a considerable shrubby and herbaceous cover. It does not, however, encourage the growth of epiphytes, and it is not rainy enough nor constantly warm enough, nor constantly cold enough, to induce the formation of much evergreen vegetation. There is rainfall enough to create an immense aquatic life, but the gradients are too steep to permit it. It is never dry enough for any length of time to support a true xerophytic vegetation, even an evanescent one. Bulbous plants, fleshy plants, thorny and "skeleton" plants, such as mark dry climates, are therefore scarce. It is true that the aspect of the vegetation changes

with the seasons. Thus in spring plants of a northern affinity are dominant, and again in autumn one sees asters, gentians, etc., that incline toward the north temperate zone, while in the long, hot summers passion flowers, sensitive vines, trumpet-creepers, etc., are rather dominant. Still, the vegetation measured as a whole belongs to the rich, beautiful, and unmatched deciduous forests of the Southeastern Highlands of the United States, in its class rivalled only by the deciduous forests of eastern Asia.

General Characteristics of the Flora

It is not the purpose of the present writer to go deeply at this point into the general characteristics of the flora, since in a sense that is best inferred from the annotated list itself. As is well known the flora of the southern Appalachians is rich in those ancient Tertiary types of plants once wide-spread over the North Temperate world, but since the Glacial Period surviving now chiefly in the southeastern United States and China and Japan. These genera, indeed, give to the flora much of its characteristic appearance, composition, and endemicity.

A marked feature of the flora of this area is its lack of great development of any one particular genus. Thus *Carex* is reduced to a very small number of species, and those principally the allies of *C. laxiflora*—specialized, atypical, woodland plants. The largest genus does not exceed thirty-five species. *Aster* and *Solidago*, so large in most parts of the eastern states, are rather poorly represented, though showing distinct endemicity. *Helianthus*, *Panicum*, *Polygonum*, have, none of them, many species. On the other hand the number of genera is very large, thus giving the flora a highly diversified aspect.

The total lack of true aquatic life has been noted; there is on the other hand almost no true xerophytic life; the number of introduced weeds is also small. It is remarkable therefore that the flora, shorn of the many species, and whole families, that swell the numbers of other floras, is as large as it is, for it is composed almost wholly and purely of the typical, virgin, mesophytic, deciduous forest types of the Carolinian and Alleghenian zones. As such, and as a flora exemplifying the Tertiary survival genera, it is of peculiar interest.

The impression which the flora makes upon the eye is somewhat different from one's impression of it when examined species by species. The eye beholds a forest of oaks and pines, with *Ericaceae* as the dominant shrubs, a region without swamps, without true meadows. An examination of the forest types soon shows, however, that there are some

seventy deciduous trees, so widely diffused and intermixed as practically to defy forest zonation into ordinary ecological classification. Still further investigation shows that the peculiar character of the flora resides most of all in the endemicity of the genera and species. Space does not permit of speaking of that endemicity in much detail at this point. Mention may be made of such genera having endemic species as *Asplenium, Trillium, Asarum, Saxifraga, Oenothera, Robinia, Rhododendron, Hypericum, Solidago, Pentstemon, Aureolaria, Thalictrum, Tilia,* etc.

ANNOTATED LIST OF PLANTS

Subkingdom: PTERIDOPHYTA (Ferns and Fern Allies)

Family 1. POLYPODIACEAE (Common Fern Family)

1. **Polypodium virginianum** L. (Common Polypody)
P. vulgare of auths. not L.

Frequent on rocks in the mountains, perhaps sometimes on the piedmont, and on the boles of trees. Specimens: Spring Mt. Pk., Aug. 14, 1897 (Towns.). North slope of Tryon Mt., March 4, 1919 (Day). On a rock, Pearson's Falls, Dec. 28, 1920, and on rocks under *Tsuga caroliniana* at "The Narrows," White Oak Mt. (PT., nos. 1570 and 1037).

2. **Polypodium polypodioides** (L.) Hitchc. (Tree Fern)
P. incanum Sw.

Epiphytic on the boles of trees. The preceding species is generally found on rocks in the mountains, this one on trees on the piedmont, but the positions may be reversed. In dry weather this fern curls up, turns gray and crisp and seems dead. A rain causes it to expand and look refreshed. The same is true, in a lesser degree, of the preceding. Specimens: Huston Farm, near Columbus, July 28, 1897 (Towns.). Trunk of a tree, Feb. 25, 1919, and on rocks, Tryon, May 3, 1911 (Day). On trees, Pearson's Falls, Sept. 3, 1921 (PT. nos. 1438, 1439)

3. **Phegopteris hexagonoptera** (Michx.) Fée. (Beech Fern)
Thelypteris hexagonopteris Weatherby
Dryopteris hexagonopteris C. Christ

In rich loam under trees, frequent in the mountains and adjacent piedmont. Specimens: Side of Tryon Range, Aug. 9, 1897 (Towns.)

Rich glen, Lynn, Aug. 20, 1921, and rich woods, Vaughan's Gap, foot of Hogback Mt., Aug. 14, 1921, and, same habitat, Sept. 16, 1921 (PT. nos. 1303, 1304, 1265, 1266, 1468).

4. **Peteridum latiusculum** (Desv.) Maxon (Brake, Braken)
Pteris aquilina of auths. but not L.
Pteris latiuscula Desv.
Pteridium aquilinum (L.) Kuhn

Very common in dry thin soils under light shade, predominantly on the piedmont. Specimens: Tryon, May, 1918 (Millsp. no. 4097) Woods, Tryon, Oct. 18, 1926 (PT. no. 2402).

4A. Var. *pseudocaudatum* (Clute) Maxon.

In dry woods, Tryon, Aug. 23, 1921 (PT. no. 1343).

5. **Adiantum pedatum** L. (Maidenhair Fern)

Common in the rich Porter loams of the mountains and the cooler shaded glens of the piedmont. Specimens: Side of Tryon Range, July 8, 1897 (Towns.). Tryon, May 1918 (Millsp. no. 4166) Mountainsides, Melrose, June 27, 1921 (PT. no. 704).

6. **Polystichum acrostichoides** (Michx.) Schott. (Christmas Fern)
Nephrodium acrostichoides Michx.
Dryopteris acrostichoides Ktze.

Common in loam, even the thin loams under evergreens, both in the mountains and on the piedmont. Specimens: Side of Tryon Range, Aug. 9, 1897 (Towns.). Tryon, May 1918 (Millsp. no. 4033).

6A. Forma *incisum* Gray (var. *Schweinitzii* (Beck) Small).

In rich woods, Tryon, Aug. 25, 1921 (PT. no. 1393).

7. **Asplenium montanum** Willd (Mountain Spleenwort)

This beautiful little endemic species is rare on the mountain gneisses and in the Ashe loam soils. Specimen: Hogback Mt., March 1928 (Kimber).

8. **Asplenium parvulum** Mart. & Gal. (Spleenwort)

This tiny fern was collected by Horsford, Dec. 1891, probably on Tryon Mt. It has not been re-discovered since that date (*Garden and Forest*, vol. 4, p. 86).

9. **Asplenium Trichomanes** L. (Spleenwort).

On rocks in or near the mountains, under deep shade, not infrequent. Specimens: Spring Mt. Pk., Aug. 25, 1897 (Towns.). On rocks, Tryon, May 3, 1911 (Day. Of this specimen Maxon notes: "subincised and more deeply crenate than usual.") On rocks in rich woods, "Valhalla," Aug. 25, 1921 (PT. no. 1396).

9A. Var. *incisum* Moore.

This plant is reported by Horsford from the vicinity of Lynn, Dec. 1891. There are no known specimens of Horsford's observations, but his reports of ferns in *Garden and Forest*, vol. 4, p. 86, may be taken as reasonably authentic.

10. **Asplenium platyneuron** (L.) Oakes. (Ebony Fern)
A. ebeneum Ait.
Achrostichum platyneuron L.

Common in the rich Porter loams of the mountain woods and piedmont glens. A characteristic and beautiful little fern of our area. Specimens: Side of Tryon Range, Aug. 10, 1897 (Towns.). Rich woods, Tryon, May 1918 (Millsp. no. 4097). In rich deep woods, Pearson's Falls, June 24, 1921 (PT. no. 661).

11. **Camptosaurus rhizophyllus** (L.) Link (Walking Fern)
Asplenium rhizophyllus L.

This curious little tip-rooting fern is a rare habitant of the richest loams of mountain forests. Specimens: Piney Mt. Feb. 6, 1919, and Gorge below Pearson's Falls, April 18, 1919 (Day). On rocks, Pearson's Falls, Dec. 28, 1920, and April 20, 1922 (PT. nos. 1562, 1678).

12. **Athyrium thelypteroides** (Michx.) Desv.
Asplenium thelypteroides Michx.
Asplenium acrostichoides Sw.

Athyrium acrostichoides Diels.
Diplazium acrostichoides Butters.

In rich mountain loams under deep shade. Specimens: By a rocky, mountain stream, Melrose, May 1918 (Millsp. no. 4170). In a very rich, shady forest, Pearson's Falls, Sept. 12, 1921 (PT. nos. 1506, 1515).

13. **Athyrium asplenioides** (Michx.) Desv. (Lady Fern)
Nephrodium asplenioides Michx.
Asplenium Filix-foemina of many authors.

Common in wet woods, rich loams, throughout, especially in piedmont woods; sometimes even in poor soil, cinders, etc. Specimens: Moist woods, "Thousand Pines," June 29, 1921. In very wet woods, "The Shoals" Aug. 20, 1921. In a marsh, on the hill south of the trestle. Aug. 12, 1921. Along the railroad tracks, Saluda, Aug. 8, 1921 (PT. nos. 761, 1318, 1203, 1114). Forma *substripinnatum* Butters. In rich soil, Tryon, Aug. 25, 1921 (PT. no. 1394).

14. **Thelypteris marginalis** (L.) Nieuwl. (Wood Fern)
Polypodium marginale L.
Aspidium marginale Sw.
Dryopteris marginalis Gray.

Frequent in rich woods in the mountains and on dripping rocks. Specimens: Spring Mt. Pk., Aug. 14, 1897 (Towns.). North slope of Tryon Mt., March 4, 1919 (Day). Pearson's Falls, on dripping rocks, Dec. 28, 1920, and Sept. 3, 1921 (PT. nos. 1561, 1442).

15. **Thelypteris noveboracensis** (L.) Nieuwl. (Shield Fern)
Polypodium noveboracensis L.
Aspidium noveboracensis Sw.
Dryopteris noveboracensis Gray

This pale green, fragrant, dainty little fern is very common by rills and brooks and in woods throughout the area. Specimens: Spring Mt. Pk., July 27, 1897 (Towns.). Rich woods, Tryon, Aug. 15, 1921. Along a brook below Godshaw Hill, July 11, 1921 (PT. nos. 1211, 982, 983).

16. **Woodsia scopulina** D. C. Eaton.

This handsome little fern is in many ways the most remarkable discovery that has been made in the Tryon flora. It is primarily an inhabitant of the Rocky Mts., but extends eastward on rock outcrops to the Dakotas, Minnesota, and the Gaspé region of Quebec. In an extremely rare and local way it has been found upon the Appalachians. The first discovery of this fern in North Carolina was made on White Oak Mt., Aug. 14, 1897, by E. C. Townsend, though the discovery of this species in the Mt. Mitchell country by Ferris in 1901 was the first published report of it from this state. Townsend's specimen sheet bears three ferns; all were considered by the collector to have been some form of *Woodsia obtusa*, though Mr. Townsend noted some difference among the three specimens and numbered them. Number 1 on his sheet is this very rare species. It has not since been re-collected. The identification of this specimen was kindly checked for me by Dr. William Maxon of the U. S. National Herbarium.

17. **Woodsia obtusa** (Spreng.) Torr.

Rare, on mountain rocks. The only collections are two made by Townsend and mounted on the same sheet with the specimen of the preceding species. These specimens may therefore be cited as: No. 2. on the sheet, White Oak Mt., Aug. 14, 1897. No. 3 on the sheet, Columbus, 1899.

18. **Filix fragilis** (L.) Gilib.
Polypodium fragile L.
Cystopteris fragilis Berngh.

Frequent on wet rocks, and along mountain water courses, in deep woods. Specimens: Side of Tryon Range, June 27, 1899. (Towns.). Melrose, May 1899 (Churchill). On wet rocks, Pearson's Falls, July 27, 1921, and Sept. 12, 1921 (PT. nos. 712, 716, 1507).

19. **Cheilanthes lanosa** (Michx.) Walt. (Lip Fern)
Nephrodium lanosum Michx.
Cheilanthes vestita Sw.

On dry mountain cliffs and rocks, frequent. Specimens: Side of Tryon Range, Aug. 2, 1897. Spring Mt. Park, Aug. 14, 1897. Tryon Mts., June 10, 1899. (Towns.).

20. **Cheilanthes tomentosa** Link. (Lip Fern)

Frequent, on dry mountain cliffs and rocks. Specimens: Skuyuka, May 1899 (Church). On rocks, Tryon, May 10, 1919 (Day). On a dry cliff, Rocky Spur, Sept. 6, 1921 (PT. nos. 1459, 1457, 1458).

21. **Dennstaedtia punctiloba** (Michx.) Moore (Hay-scented Fern)
Nephrodium punctiloba Michx.
Dicksonia punctiloba Ktze.

Occasional in shady woods. Specimens: Side of Tryon Range, Aug. 9, 1897 (Towns). Tryon, May 1918 (Millsp. no. 4145). Hog-back Mt., March 1928 (Kimber).

22. **Lorinseria areolata** (L.) Presl. (Chain Fern)
Acrostichum areolatum L.
Woodwardia angustifolia J. E. Smith
Woodwardia areolata Moore.

This curious fern is predominantly a plant of the coastal plan, and is rare in this area. It is so far known but from a single locality in a marsh on top of a hill, on the state line, beyond the trestle. Specimen: Aug. 12, 1921 (PT. nos. 1195–1197).

23. **Onoclea sensibilis** L. (Sensitive Fern)

Rather frequent in rich woods throughout, especially the foothills. Specimen: Under beeches, "Valhalla," July 23, 1921. Sterile frond only (PT. 1049).

Family 2. OSMUNDACEAE (Cinnamon Fern Family)

24. **Osmunda regalis** L. var. *spectabilis* (Willd.) Gray (Royal Fern or Flowering Fern)

Frequent in rich woods along brooks, in the mountains and foothills. Specimens: Spring Mt. Pk. June 22, 1899 (Towns.). In a brook on Little Warrior Mt., April 19th, 1919. On a rocky island in Vaughan's Creek, below Godshaw Hill, June 29, 1921; same habitat, April 10, 1922 (PT. nos. 0135, 728, 729, 1611).

25. **Osmunda cinnamomea** L. (Cinnamon Fern)

Not frequent; in low alluvial soils with poor drainage. Some clumps were observed in marshy ground on top of Hogback Mt. in 1919, but this habitat is now largely changed. Specimens: Spring Mt. Pk., June 8, 1899 (Towns.). In low woods at "The Shoals," May 1918. (This is a sterile frond collected by Millspaugh and called by him "*Matteucia Struthiopteris*," no. 4156, but it proves to be the cinnamon fern.)

26. **Osmunda Claytoniana** L. (Interrupted Fern)
O. interrupta Michx.

Very rare, in low wet woods, Columbus. The only collection of this curious fern is that by Townsend, in 1899.

Family 3. OPHIOGLOSSACEAE (Adder's Tongue Family)

27. **Botrychium virginianum** (L.) Sw. (Rattlesnake Fern)
Osmunda virginiana L.
Botrychium gracilis Pursh
Botrypus virginicus Michx.

Frequent in rich soil of forests in the mountains and foothills. Specimens: May 20, 1897, Columbus (Towns.). Rich woods, Vaughan's Gap, between Hogback and Rocky Spur, Aug. 14, 1241. Rich woods, Pearson's Falls, April 20, 1922 (PT. nos. 1241, 1672).

27A. **Botrychium obliquum** Muhl. (Moonwort)
B. ternatum var. *obliquum* D. C. Eaton
B. dissectum forma *obliquum* Fernald

There are several fragmentary specimens of this species from our area. Dr. Maxon of the National Herbarium has expressed himself as too doubtful both of the specimens and of the innumerable leaf-shape varieties described under this species to place these more definitely than in this polymorphic species. Specimens: "Dark Corners," April 1928 (Kimber). Miss Wright in her list records *Botrychium ternatum*, but this must certainly be an error.

Family 4. EQUISETACEAE (Horsetail Family)

28. **Equisetum praealtum** Raf. (Horsetail)

This is certainly among the plants frequent elsewhere but uncommon here, as the sole collection is by Townsend at the "Huston Farm,"

between Columbus and Millspring, June 4, 1899. *E. praealtum* is one of the groups of variations that has frequently been called "*E. hyemale* L." a species really confined to Europe.

Family 5. LYCOPODIACEAE (Club Moss Family)

29. **Lycopodium lucidulum** Michx. var. **porophilum** (Lloyd & Underw.) Clute (Club Moss).

A specimen of this interesting little species was sent me by Mrs. Gertrude Ludlom from cool woods of White Oak Mt. in the summer of 1925. So far this constitutes the sole record of a *Lycopodium* from our area, but it is likely that more will be discovered on the higher mountains; there are several other species in Henderson, the adjoining county.

Family 6. SELAGINELLACEAE (Selaginella Family)

30. **Selaginella rupestris** (L.) Spreng. (Selaginella)
Lycopodium rupestris L.

Frequent on dry mountain cliffs, on the granites and gneisses. Specimens: Tryon Mt., May 1899 (Church.). On rocks under *Tsuga caroliniana* at "The Narrows," White Oak Mt., July 21, 1921 (PT no. 1040). There are two distinct vegetative phases of this species in our area. The commoner forms compact, upright clumps, recalling the habit of the common moss, *Polytrichum commune*. My specimen from The Narrows is of this type. . Another phase is prostrate, widely branching, and loosely spreading. Churchill's specimen is of this phase and superficially looks more like typical *S. tortipila*. There are no reproductive characters on which to separate these two phases, and it is my final conclusion that strikingly different as they look in the field, they deserve no taxonomic separation. The widely spreading phase seems to have something of a geographic range of its own in the specimens in the National Herbarium, namely, mountains of Maryland to Tennessee Georgia, and Alabama, and rocks of Missouri and Illinois. This range restriction might break down in the examination of more specimens, however.

31. **Selaginella tortipila** A. Br.
S. rupestris var. *tortipila* Underw.

Rare, on dry mountain cliffs. Specimen: On the southwest ridge of Hogback Mt., in low mediacid soil, May 27, 1927 (Wherry).

Besides the foregoing *S. apus* (L.) Spring., a tiny moss-like plant, very easily overlooked and quite possibly present in moist shady woods, was noted by Woolson on Tryon Mt., according to correspondence with him. No specimen.

Family 7. ISOËTACEAE (Quillwort Family)

32. **Isoëtes Engelmanni** A. Br. (Quillwort)

This singular and easily overlooked little species is usually considered a plant having a preference for the clay-bottomed ponds of the northern coastal plain. Its presence in our flora is remarkable, and it has as a matter of fact never been collected here but once, by the Biltmore Herbarium, specimen no. 5564, May 5, 1897, "in bogs found by cold springs on Spring Mt., near Columbus, at elevation of 3000 ft." "Bogs" and "Spring Mt." are designations unfamiliar in any literal sense to the present writer, as there are no bogs, but merely somewhat seepy ground around mountain springs, and the "Spring Mt." of the last century generally means what we now call White Oak Mt. This specimen, in the Gray Herbarium, was marked "var. *caroliniana*" in the handwriting of the distinguished fern specialist, A. A. Eaton. But Dr. N. E. Pfeiffer whose recent monograph of *Isoëtes* is taken as a modern standard, has labelled it true *Isoëtes Engelmanni*.

Subkingdom: SPERMATOPHYTA (Seed Plants)

Subdivision I. GYMNOSPERMAE ("Conifers" and their Allies)

Family 8. PINACEAE (Pine Family)

33. **Pinus Strobus** L. (White Pine)
Strobus Strobus Small

Locally abundant but not one of the common pines of the region. It occurs in its greatest numbers at the headwaters of the Pacolet River, south of Saluda, on the low, dome-like tops of the mountains there. It is also found around the headwaters of the Saluda River, on the "farther" or western side of the pass between Hogback and Rocky Spur, and, in a scattered way, in high, dark coves of Buck Mt., Green River Gorge, etc. There is even a colony of white pines in a cove along Vaughan's Creek, on the North Carolina-South Carolina state line, by the rail-

road trestle (my specimen: Aug. 12, 1921, no. 1200), which is rather an unusual locality, for North Carolina, being down at 900 ft. above sea level. Flowers in April.

34. **Pinus echinata** Mill. (Short-leaf Pine. Yellow Pine. Rosemary Pine)

P. squarrosa Walt.

P. mitis Michx.

This is perhaps the commonest pine of the area, and, so far as huge old specimens are considered, all in all the most imposing. A local name for this pine is "armored pine" on account of its great plate-like segments of bark. Sometimes this is called Old Field Pine, but that name is used also for *Pinus Taeda*. This pine has a preference for the well-drained slopes of foothills, ridges, and rich glens and coves, and may occur in a scattered way among hardwoods of either the Alleghenian or Carolinian forest types, or it may form large and imposing stands of its own. In the extreme eastern parts of the county the loblolly and scrub pines are important rivals to it; in the higher mountains it takes its place beside the pitch and white pines. But in the best-known part of the Tryon region, that is, the foothills, mountain spurs, and upland glens that follow at the foot of the Blue Ridge escarpment it is the dominant pine and, in the winter scenery, the dominant tree. Specimen: Godshaw Hill, Tryon, Aug. 23, 1921 (PT. no. 1360). Flowers in April.

35. **Pinus Taeda** L. (Loblolly Pine. North Carolina Pine)

A common name for this species is "Old Field Pine," from its habit of springing up in fields abandoned from cultivation, or logged-over, stumpy land. An important commercial tree in the central parts of the state, it is somewhat infrequent here except in the little-visited, low, hot, and sandy eastern portions of the country. My specimen, no. 1600, Sept. 17, 1921, is taken from a noteworthy example of this tree—an individual specimen of gigantic size and what must be a century and a half of growth, growing on the terraces of the estate called "Lyncote." This superbly beautiful tree is the finest of its species I have ever seen, and is remarkable for being on a hill that is practically an extended spur of Melrose Mt.—perhaps the Loblolly pine that is closer to the mountains than any other in the state. Flowers in April.

36. **Pinus virginiana** Mill. (Scrub Pine. Spruce Pine. Jersey Pine) *P. inops* Ait.

This nearly worthless, straggling pine makes up the common "pine scrub" areas of the eastern, low, hot, sandy parts of the county, and is by no means infrequent in the foothills. While it is generally not found on the rich soils of the slopes of high hills, mountain glens and cliffs, it does sometimes occur in the mountains, in Porter sand, where the ground is sterile and thin and level. The name "Nigger Pine" is locally applied by country people (not by the town dwellers) for no more obvious reason than as a designation of inferiority, which it deserves. It is never beautiful except when a large number of saplings come up close together, forming dark thickets, with dead underbranches, when the name "Spruce Pine" is somewhat deserved, as the effect is that of a little forest of spruce trees. Specimens: Columbus, Apr. 27, 1899 (Towns.). Dry woods, Tryon, Aug. 20, 1921 (PT. no. 1376). Southwest ridge of Hogback Mt., May 27, 1927 (Wherry). Flowers in April.

37. **Pinus pungens** Lamb. (Table Mountain Pine. Burr Pine)

On poor, thin, granitic soils, a tree characteristic of the Carolina Blue Ridge and its eastern spurs, and in our area locally abundant, but scarcely a common tree. It is found in considerable numbers on Piney Mt., and on the narrow ridge connecting it with Melrose Mt., as well as on White Oak and other mountains. It is a worthless tree commercially and would be no more attractive in general appearance than *Pinus virginiana* but for its remarkable cones with their sharp spines. Occasionally a tree is seen that is simply a mass of these formidable, handsome cones. This tree derives its common name from being abundant on the famous Table Mountain in the Linville section. Specimens: Tryon, May 1918 (Millsp. no. 4106). Tryon, May 4, 1919 (Day). In dry soil, Tryon, Aug., 26, 1921 (PT. no. 1400).

38. **Pinus rigida** Mill. (Pitch Pine. Mountain Pine. Black Pine)

Common in the mountains and adjacent piedmont, chiefly on dry, rocky, poor soil and exposed ridges, singly or in considerable stands. This picturesquely handsome tree exists in considerable quantities here but the specimens are usually so contorted by the elements as to be valueless commercially though a joy to the eye, from their selection of cliffs and such bold mountain spots for growth. Frequently a consider-

able portion of the tree may be dead. Black dense clusters of old cones, still hanging on, are common in the trees of our area. Specimen: Piney Mt., April 1928 (Kimber).

39. **Tsuga canadensis** (L.) Carr. (Common Hemlock)
Pinus canadensis L.
Tsuga americana Mill.

This handsome tree is frequent in dark cool coves in the higher mountains, particularly the headwaters of the Saluda, Pacolet, and Green Rivers, Pearson's Falls, Vaughan's Gap, etc., It is usually associated with the beech, and the undercover of herbaceous plants accompanying these two trees goes, with these trees themselves, to make up the typical mountain or cool-temperate flora as it occurs in our area. Specimen: Melrose, March 25, 1919 (PT. no. 026).

40. **Tsuga caroliniana** Engelm. (Carolina Hemlock)
Abies caroliniana Chapm.

This beautiful but useless little tree is in our area an inhabitant of rocky cliffs and prominent positions near the summits of the mountains. Indeed, there is almost a *Tsuga caroliniana* zone, for I have never seen it occur on any mountain summits, nor near the bases of the mountains. It occupies a narrow zone at about two thousand feet, and by its dark green color, may be picked out with the naked eye, even from the valleys, as a band of trees. I have never seen it in rich deep soil, nor on gentle slopes, but always on bold mountain promontories among outcroppings of rock. It is present on White Oak Mt. at "The Narrows" and also, to a lesser extent on the northward facing slope of Tryon Mt. It also occurs on Buck Mt., on Hogback and Rocky Spur. and probably on Wild Cat Spur and others of the little known peaks in the northern parts of the county. Specimen: "The Narrows," White Oak Mt., Sept. 16, 1921 (PT. nos. 1596, 1597). Sargent in "Silva of North America," vol. 12, p. 70, states that it occurs in common with *Tsuga canadensis*. This is with us emphatically not the case, the northern hemlock choosing the rich dark soil of cool, shaded mountain glens, and I am inclined to believe that nowhere is the Carolina hemlock closely associated with the other species.

A bit of unpublished botanical history centers around the Carolina hemlock. First discovered in 1837 by Lewis Reeves Gibbes of Charleston, S. C., on Table Mt., Pickens Co., S. C., it was recognized by Gibbes

as something unusual, although he called it, as many naturalists in his day would have done, a *Pinus*, and at other times "a fir, *Abies*." Indeed the mountaineers still speak of it at times as a fir because, like the branches of *Picea*, its needles bristle out in all directions from the branches, instead of lying in one plain like that of the northern hemlock. He called the attention of Asa Gray to this tree in his letter of the second of August, 1856 (unpublished letter in the Gray Herbarium) but Gray seems to have replied to the effect that he could see no difference between the specimens sent him and the common hemlock. On Aug. 19th Gibbes retorted hotly that "we are both *advancing in years* (if not in wisdom!) but I can scarcely think either of us has yet lost his eyesight. So you think *P. laxa*" (Gibbes' name for the new species, never actually published as a new name) "is like or the same as *P. canadensis!*" And much more in the same vein. "On my first view of it in 1837 *P. canadensis* never entered my mind, growing (as it did) on the edge of a cliff 200 feet high, in a position *P. canadensis* is not found." Gibbes was right, though it was Engelmann who finally, in 1881 gave it its accepted name.

41. **Juniperus virginiana** L. (Red Cedar. Juniper)
J. caroliniana Mill.

The well-known Virginia Cedar that is abundant in the middle portions of the state, is rare in our region, as a native plant, though it is much planted for ornament around old farmhouses. It occurs occasionally in a state certainly spontaneous in pastures and woodlands of the eastern part of Polk County but is rare near or in the mountains, although at 1500 ft. altitude on White Oak Mt., I once saw the largest and probably the oldest juniper I ever beheld, growing on a great rock and intermixed with deciduous trees. Seedlings are becoming common on the Congaree fine sandy loams. Specimen: Tryon, April 10, 1923 (PT. no. 1835). Flowers in March.

TRYON, N. C.

[*To be continued*]

OBSERVATIONS ON AMOEBIDIUM PARASITICUM CIENKOWSKI

By Wm. Randolph Taylor

Plate 7

In preparing a report upon some plankton catches of algae and crustacea from lakes and tanks in Arizona (9) a number of organisms were encountered on crustacea which were assigned with little question to *Characium*, or perhaps to *Characiopsis*, since in preserved decolorized samples the choice between these genera was not easily made. When the final detailed study of the organisms was made it was found that one of them reproduced in a peculiar fashion, quite inappropriate to the genera mentioned, and the report was laid aside for some months awaiting a clue to the systematic position of the strange individuals.

Meanwhile, on a suggestion that the cultures of *Daphnia* in the University vivarium might yield *Characium*, an examination was made of the large culture tanks. Instead of recognizable algae, the *Daphnia* bore two obviously different colorless organisms: one a filamentous type, probably a fungus mycelium, forming a whitish halo about the swimming animals, and the other arcuate, sub-cylindrical cells that were clearly co-generic with the Arizona plants. The cultures had been started from material in all probability derived from swamps in the southern part of Philadelphia. The arcuate cells ultimately proved to be a species of *Amoebidium*.

The organisms were solitary or numerous, not definitely clustered, elongate, the cells straight or more often slightly arcuate to occasionally sigmoid or falcate and rarely circinate; the ends of the mature cells were slightly tapering, obtusely rounded; young cells were lunate, developing to the mature state; the base was attached by a thick, slightly lobed, very pale yellowish to pale dull brown pad or cushion of (?) mucilaginous material; the mature vegetative cells were 32–464μ long, generally about 200–300μ, and 6.6–11.4μ in diameter, the average being 9.5μ; vegetative cells showed at first a single submedian series of 4–20 or more nuclei; reproduction occurred by the formation in sporangia 7.6–12.6μ in diameter, 47–378μ (perhaps more) in length, of curved spores which

are discharged from several, probably individual pores; or reproduction by amoebae usually about 5.7μ wide by 13μ long formed in cells similar to the vegetative ones, about 9.5μ in diameter, and discharged from a single pore near the base of the sac.

Since this Pennsylvania organism was quite unfamiliar when first seen, care was exercised to determine the presence of chlorophylloid pigments, mainly by the use of complementary filters of known transmission, without success. A suggestion kindly made to the writer that the organism was a member of the Characeae decolorized as the result of immediate adaptation to a saprophytic habit in the putrid culture was tested by transferring the *Daphnia* to rather pure water in a brighter light, but no change took place in the *Amoebidium* cells within the time the *Daphnia* survived this treatment. It was by chance during these observations that the amoebae were noticed emerging from an amoebosporangium on a crushed mount, and the curious life history fully appreciated. Later, following further suggestions kindly made, a few tests were made of the wall-substance of the *Amoebidium* cells. The natural test was for cellulose, to see how clearly this plant character might be established. Tests were made several times with aqueous iodine followed by 70 per cent sulphuric acid, securing at first a dull yellow coloration of the wall, which after a few hours disappeared while the wall swelled to a slight degree. Comparisons run at the same time with cellulose from filter paper and cotton cloth gave fine blue reactions, others with mycelium of *Rhizopus nigricans* gave a dull violet reaction, and those with mycelium of *Agaricus campestris* simply gave a yellowish reaction. Other lots of material were soaked for 3 hours in strong caustic potash and in strong hydrochloric acid, but the *Amoebidium* was not able to survive this, though the *Daphnia* skeleton remained largely intact. The earlier reports to the effect that the wall of *Amoebidium* did not give a cellulose reaction seem to be confirmed, although this test is notoriously difficult with algae, and the test for fungus cellulose is not altogether satisfactory.

The progress of events in the amoebosporangia is of considerable interest. The ripe ones may be recognized (with some uncertainty) by denser cell contents and irregularly placed nuclei. At the time a certain one was brought into the field of view it was of even contour, with scattered nuclei and the contents quite quiet. It was soon seen that larger granules in the cell had begun to vibrate actively as if by Brownian movement, and at the end of two minutes the protoplast had divided up and begun to separate. As the individual daughter cells rounded up

the contour of the amoebosporangium became distinctly knobby. At the end of the third minute the first amoeba began to squeeze out from a small pore at the bottom and back of the sac, just above the attaching pad. With the passage out of a few amoebae those remaining moved about inside, and by the time four had left the sac began to contract at the apex, collapsing downwards as the amoebae passed out and keeping close to the uppermost individual, becoming wrinkled and longitudinally contracted. It took two minutes for all 16 amoebae to emerge, or five altogether from the time observations were started. In five more minutes all of the amoebae had left the field except one, and the amoebosporangium wall had completely disappeared except for the basal pad. In another case the discharge was watched from an amoebosporangium that formed but 4 amoebae. These came out from a small pore near the base, as always, and were 5.7μ wide by 13μ long: just the average dimensions, as it happened. The empty amoebosporangium immediately disappeared. In general the separation walls between nuclei in the amoebosporangia or vegetative cells were not visible in living or stained preparations until formation of motile cells was imminent.

The size of the amoebae has been mentioned. In shape they are pyriform or with a somewhat slender posterior portion which terminates in a rather distinct dense tip that appears almost like a spine. The nucleus always keeps near the anterior broad end, and with it there are usually several refractive granules, probably of food. Motion is of a rolling type, the protoplasm appearing to flow over the front of the little amoeba and resting in contact with the substratum. Frequently, as when the direction of travel was about to change, the anterior end became bilobed, but this was always only momentary. The further fate of the amoebae was not studied, but has been reported by earlier students. The rate of progression seems to be about 33μ in 10 seconds, on the basis of 15 measurements made at 10 second intervals and involving 3 individuals, but without allowing for the somewhat vacillating path. The general trend was remarkably direct, the amoebae tending to pass as quickly as possible out of the brilliant glare of the highly illuminated field of view to the shaded parts of the slide.

The behavior of the arcuate spores is not quite so theatrical. When their time for discharge has arrived they move jerkily out of the many pores. It is probable that there is potentially a separate pore for each spore, though these may unite. The uppermost spores generally pass out first, and then those further down in rapid succession. The speed with which they come out gives the impression that they are being

forced from within, but the old membrane becomes progressively longitudinally wrinkled. The spores may remain attached for some time, and earlier writers describe their germination and continued growth in this position. In the writer's material they usually were soon liberated, but might stay in place until the nucleus had divided to four daughter nuclei. On the other hand, many spores were seen attached here and there about the *Daphnia* carapace which were still very small and had but a single nucleus. When first extruded they are very flexible, and usually change shape perceptibly, from a more plump to a more cylindrical form. The empty sporangium membrane is persistent, even long after all of the spores have been displaced.

Material of this organism is also available from North Carolina, collected in April 1926 on *Daphnia* and *Simocephalus* near Chapel Hill by Prof. R. E. Coker. So far as recognized in the specimens sent to the writer, the cells were a little smaller (5.7μ) in most cases than those from Pennsylvania, but reached only a comparatively moderate length, and were probably not full-grown. Unquestionably they were of the same species. Another organism resembling *Characiopsis* in shape was also present, but of course decolorized and perhaps not determinable.

DISCUSSION

A paper by Cienkowski (4) is the basis for our knowledge of the genus *Amoebidium* and its name. In general the morphology of the plant is the same as that described for the Pennsylvania material. Two reproductive methods are described. The first of these is by the formation of curved spores in somewhat swollen vegetative cells. The second is by small amoebae formed in the mature cells, or even in the daughter cells (spores) before they are liberated. The amoebae after a period of motility produce cysts of which the character and behavior varies according to the season, but in general eventuates in the production of miniature curved spores that emerge to form new vegetative *Amoebidium* cells of normal size. Cienkowski was inclined to think that *Amoebidium* was a genus of plants related to the lower algae or the fungi. Moniez (7) carries this idea to the unfortunate climax of suggesting relationship with *Rhaphidium* of the Palmellaceae which in modern nomenclature would be *Ankistrodesmus* of the Scenedesmaceae, because both have a somewhat similar shape and form spindle or lunate cells internally. The similarity to *Harpochytrium*, a genus of Chytridiaceous fungi, is more perfect, and this genus was suggested to the writer by several persons as a possible resting place for his material. A sufficient idea of

this genus may be secured from papers by Atkinson (1, 2), or a more recent treatment by Scherffel (8). The shape may certainly be remarkably similar, and likewise the arrangement of the nuclei. However, the fungal genus does not appear to produce the curved spores. It is reported to retain a small sterile cell at the base of the sporangium at the time of the formation of the zoospores, which are characteristically flagellate. However, they are also evanescently quite amoeboid when first discharged, and may only subsequently develop the flagellum. This, with the features of general morphology, is certainly suggestive. However, these zoospores are discharged from the widely open apex of the sporangium, whereas *Amoebidium* discharges variously: in all observed by the writer, from near the base. However, the genus *Amoebidium* does not seem to have appealed to the mycologists, and retains a somewhat precarious home among the *Incertae sedis* of the Sporozoa of protozoologists. Bütschli (3) and Minchin (6) agree in general in this matter, the latter uniting a few other genera with *Amoebidium* in the subclass Exosporidia of Perrier. They both depend largely on the Cienkowski account. The only available systematic treatment of the genus is that of Labbé (5), who admits 4 species, of which at least the 2 of Moniez (7) are imperfectly known, and *A. parasiticum* is given as but 50μ long, probably by error, as the original grants a maximum length of 500μ. Schröter (in Engler-Prantl, Die Natur. Pflanzenfam., 1 (1), p. 41, 1889) discusses the genus in a chapter supplementary to the Myxomycetes, recognizing the similarity of the developmental cycle. While the plant characteristics of *Amoebidium* appeal to the present writer very strongly, he is not possessed of new data sufficient to justify any constructive suggestions respecting the disposition of the genus. It certainly presents interesting possibilities as a connection between primitive fungi and organisms now classed as protozoa.

SUMMARY

The colorless organism *Amoebidium parasiticum* is recorded from American stations as growing upon *Daphnia* and *Simocephalus*. In harmony with previous accounts it is reported as reproducing by nonmotile spores and by amoebae, the discharge of each type being described. A detailed morphological study of individuals from Pennsylvania is reported in justification of the specific determination.

ACKNOWLEDGMENT

The writer desires to acknowledge most gratefully the assistance of Professor W. C. Coker in the recognition of this organism, in introducing him to the literature regarding it, and in securing material from North Carolina through the generosity of Professor R. E. Coker.

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BIBLIOGRAPHY

(1) ATKINSON, G. F. The genus *Harpochytrium* in the United States. Annales Mycologici **1**: 479–502. 1903.
(2) ATKINSON, G. F. Note on the genus *Harpochytrium*. Jour. Mycology **10**: 3–8. 1904.
(3) BÜTSCHLI, O. Protozoa. (In:) H. G. Broun: Klassen und Ordnungen des Thier-Reiches, I Abt., Sarkodina und Sporozoa: 611–614. 1882.
(4) CIENKOWSKI, L. Über parasitische Schläuche auf Crustaceen und einigen Insektenlarveen (*Amoebidium parasiticum*). Bot. Zeit. **19**: 169–174. 1861.
(5) LABBÉ, A. Sporozoa. (In:) Das Thierreich. Lief. **5**: 180 pp., 1899.
(6) MINCHIN, E. A. The Sporozoa. (In:) E. Ray Lankester, A treatise on zoology. Part 1, Fasc. **2**: 312–315. 1903.
(7) MONIEZ, R. Sur des parasites nouveaux des Daphnies. Compt. Rend. Acad. Sci. (Paris). **104**: 183–185.
(8) SCHERFFEL, A. Beiträge zur Kenntnis der Chytrideen. Arch. Protistenk. **53**: 1–58, 1925; **54**: 167–260, 510–528. 1926,
(9) TAYLOR, W. R., AND H. S. COLTON. The phytoplankton of some Arizona pools and lakes. (To appear in Amer. Jour. Bot.)

EXPLANATION OF PLATE 7

Fig. 1. Young individual, hardly enlarged beyond the spore stage, and with but four nuclei. ×487.

Figs. 2, 3. Older individuals, potentially mature. Vacuoles are often present between the nuclei. ×487.

Fig. 4. Individual in early reproductive stage, probably to produce spores since the diameter is unusually large for the amoebosporangium. ×487.

Figs. 5–7. Spore formation, in each case cell reorganization complete and the spores morphologically ready for discharge. ×487.

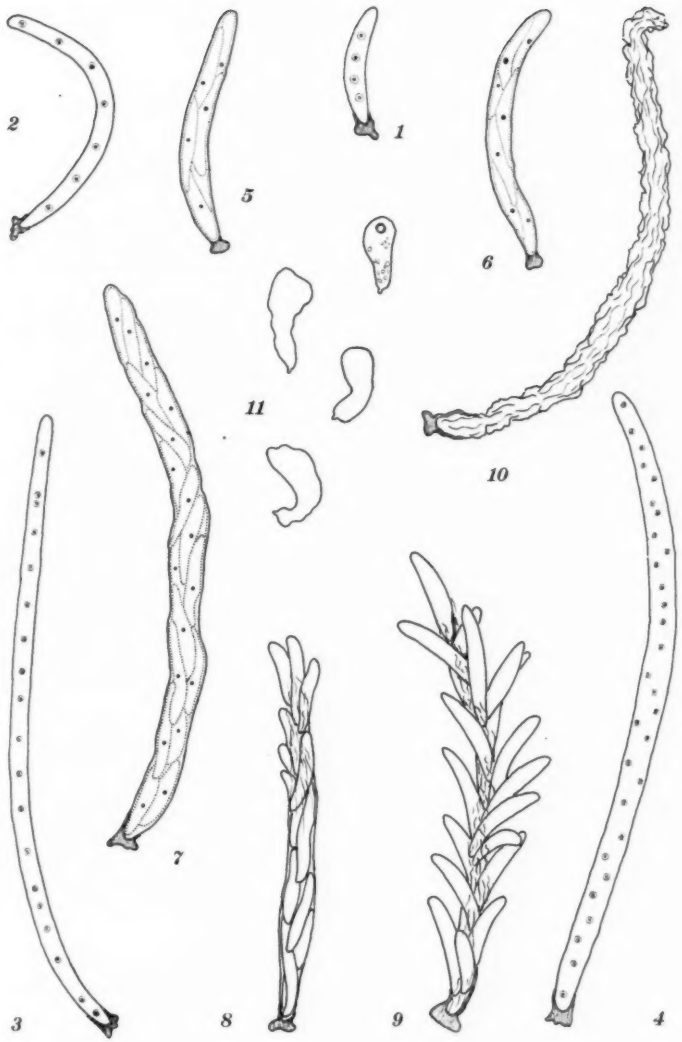
Fig. 8. Beginning of spore discharge, a few of the upper spores having partially emerged. ×487.

Fig. 9. Exserted stage of spore discharge, the spores attached, one end remaining on or generally within the sac. ×487.

Fig. 10. Empty sporangium after the spores have broken away, showing the wrinkled character. ×487.

Fig. 11. Amoebae formed as reproductive elements. These drawings were made as correctly as possible in view of the rapidly changing shape of the individuals. ×780. Figures showing the stages in the formation and discharge of the amoebae were unsatisfactory owing to the rapid change of conditions within the amoebosporangium.

PLATE 7



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STUDIES ON THE FREQUENCY OF WATER MOLDS IN THE SOIL

By KENNETH B. RAPER

In a number of articles in this Journal, beginning with Mr. Harvey's in 1925 (vol. **41**: 151), it has been shown that water molds of the family Saprolegniaceae and other related families are a normal and abundant constituent of the soil flora. All types of soils and all localities extending over distant regions of the United States, that have been tested, yield these fungi, and it is probable that their distribution is universal. Up to the present, however, no investigation has been made of quantitative occurrence, that is (1) The number of species that can be obtained from a certain definite, marked off area of soil surface; (2) The number of individual cultures that can be obtained from a given volume of soil.

It was in an attempt to throw a little light on these questions that the writer undertook the investigation described below as his work in botany for the past year.

This work was done under the direction of Dr. W. C. Coker and Dr. J. N. Couch. My thanks are due to them and also to Miss Velma Matthews for help in the determination of species.

To test the number of species occurring in a given area, six separate localities showing different types of soil and plant growth were chosen. Plots were marked off 35 inches square in each case, and these divided by lines into 49 equal 5-inch squares. In each case a single collection of the usual amount of earth, several cc. (not measured) was taken. After taking each collection the trowel was disinfected by dipping in 40 per cent alcohol. Material was cultured in the usual way (as explained in previous papers by Harvey, Coker, *et al.*) and examined once or twice as indicated under each table.

The cultures were made with the object of studying the water molds present and were not particularly adapted to encourage the growth of other types of fungi. Others occurred, however, in considerable numbers, as was to be expected, particularly aerial molds of the Mucor type and Fungi Imperfecti. These were not studied specifically but are incidentally noted in the results given.

The tables with their explanations follow:

SERIES 1

Alfalfa field about 2½ miles east of Chapel Hill; soil "white store" fine sandy loam. Collections made Feb. 28, 1928. Cultures examined Mar. 5.

5 in. ↔ / 5 in. ↕ 1	Achlya flagellata Brevilegnia linearis 2	3	Achlya flagellata Pythium sp.? 4	Allomyces arbuscula 5	Achlya flagellata 6	Achlya flagellata Aphanomyces caudata 7
Achlya flagellata 8	Achlya racemosa 9	Achlya racemosa Brevilegnia linearis Pythium proliferum 10	11	Achlya flagellata Pythium sp.? 12	A. flagellata 13	Brevilegnia diclina? 14
A. flagellata 15	16	A. flagellata 17	A. flagellata 18	Allomyces arbuscula 19	A. flagellata 20	A. flagellata 21
22	A. flagellata 23	24	A. flagellata 25	26	Brevilegnia linearis 27	A. flagellata Parasites on Achlya hyphae and oogonia. Brevilegnia linearis 28
29	A. flagellata 30	A. flagellata Brevilegnia linearis 31	A. flagellata 32	Pythium de Baryanum 33	Pythium de Baryanum 34	Brevilegnia linearis Allomyces sp.? 35
Achlya flagellata Brevilegnia diclina 36	Pythium proliferum 37	A. flagellata 38	Mucor 39	40	A. flagellata 41	42
Brevilegnia linearis B. unisperma (?) A. flagellata 43	44	A. flagellata Brevilegnia linearis 45	Mucor 46	47	Achlya flagellata 48	Mucor 49

SERIES 2

Same alfalfa field as in Series 1 but in a damper place. Collections made April 19, 1928.

Achlya flagellata 5 in. 1	A. flagellata Mucor 2	Brevilegnia diclina A. flagellata 3	Achlya sp.? (flagellata?) 4	A. flagellata 5	A. flagellata 6	Achlya imperfecta *or* A. flagellata 7
Achlya imperfecta 8	A. flagellata 9	10	A. flagellata 11	Achlya sp.? 12	A. flagellata 13	A. flagellata 14
A. imperfecta 15	A. flagellata 16	17	A. flagellata 18	Brevilegnia linearis A. flagellata 19	A. flagellata 20	A. flagellata 21
A. imperfecta 22	Brevilegnia linearis A. imperfecta 23	A. flagellata 24	A. flagellata 25	Achlya (lost) 26	A. flagellata 27	A. flagellata Pythium sp.? 28
A. flagellata Allomyces arbuscula 29	A. flagellata *or* imperfecta B. linearis 30	A. flagellata 31	A. flagellata 32	A. flagellata Mucor 33	A. imperfecta 34	A. imperfecta 35
A. imperfecta *or* flagellata 36	37	Achlya sp.? 38	A. flagellata 39	A. flagellata 40	A. imperfecta 41	Allomyces arbuscula 42
A. flagellata 43	A. flagellata 44	Achlya sp.? (flagellata?) 45	A. flagellata 46	A. flagellata 47	A. imperfecta 48	*No collection* 49

SERIES 3

In Arboretum of the University of North Carolina, in rather poorly drained soil under an oak tree (Durham sandy loam); grass and moss collected with the soil. Collections made Feb. 21. Cultures examined Feb. 24 and again Feb. 28.

5 in. ↕ / 5 in. ↔ 1	Mucor 2	Pythium sp.? 3	Mucor 4	Mucor 5	Delicate mold with many resting bodies 6	7
Mucor 8	Pythium sp.? (very delicate) 9	10	11	12	Pythium proliferum 13	Pythium sp.? (very delicate) 14
Pythium sp.? 15	16	17	18	Mucor 19	20	Mucor 21
Ascomycete Mucor 22	Same as No. 6 23	Pythium sp.? 24	Mucor 25	Pythium sp.? 26	Mucor 27	Pythium 28
29	30	Achlya racemosa 31	Pythium proliferum Mucor 32	Achlya flagellata Pythium sp.? 33	Achlya 34	Pythium sp.? Achlya racemosa 35
Achlya flagellata 36	Mucor 37	38	Achlya imperfecta 39	Achlya sp.? 40	Achlya sp.? 41	42
Mucor 43	Pythium proliferum 44	Achlya sp.? 45	46	47	Achlya sp.? 48	Achlya sp.? Pythium monospermum 49

SERIES 4

From the same alfalfa field as studied in Series 1 and 2 a more sandy area was selected and collections made in the same way, April 5, 1928. So little was found that the results can be easily expressed without a table. The only water molds found were Pythiums, *P. proliferum* in block 26, and an unidentified species of *Pythium* in 28 and 35. Mucors were found in seven of the blocks and an Ascomycete in one.

SERIES 5

Still another series was taken from the same alfalfa field, May 23, 1928; soil well drained with a dense growth of blue grass. The results may easily be expressed without a table. *Allomyces arbuscula* was found in squares 16, 19, 22 and 34; *Achlya racemosa* in squares 35 and 42; *Achlya flagellata* in squares 14 and 28; *Achlya imperfecta* in square 6; Pythiums in squares 10 and 18; Mucor in square 26.

SERIES 6

This series was taken from an upland pine grove used as part of a cow pasture (McFarland's Dairy about 2 miles east of Chapel Hill). Soil white store fine sandy loam. Collections made April 12, 1928. Results as follows: *Achlya flagellata* appeared in squares 31 and 36, *Achlya racemosa* in square 19, *Pythium proliferum* in square 29, *Pythium* species (?) in square 23, Mucors in five of the squares and an Ascomycete in one.

It was next undertaken to test the actual number of individual water molds that could be isolated from any given cubic centimeter of earth. At three separate places in the alfalfa field above mentioned a single cc. of earth was taken near the surface from a larger block sample of earth brought in. Each was then mixed with 100 cc. of sterile distilled water and the mixture divided into 10 equal parts and to each part 20 more cc. of sterile distilled water was added. This gave 3 series of 10 cultures each, each series representing a cc. of earth taken from the alfalfa field. We will call these three series A, B and C. A boiled hemp seed was put into each dish which now contained about 30 cc. of water and one-tenth of one cc. of earth.

In the 10 A cultures *Pythium proliferum* appeared in two and Mucors in three. In the B series *Achlya flagellata* appeared in four, *Allomyces arbuscula* in one and a species of *Pythium*, undetermined, in four. In series C *Brevilegnia linearis* appeared in one, *Allomyces arbuscula* in one, *Pythium proliferum* in five and a species of Mucor in one.

From an open area west of the Episcopal Church densely covered with grass and weeds (soil Appling sandy loam), four cubic centimeters were taken in the same way and treated in exactly the same manner as the above three samples. We will call these four series D, E, F, G. Sample D was taken from a well drained place under a dense growth of grass; sample E somewhat lower down with less grass and more clover,

plantain, etc.; sample F still further down, not far from a ditch in a dense growth of clover and little grass; sample G on the other side of the ditch in a dense growth of plantain, clover and grass.

MOLD	TIMES COLLECTED	PLACE AND DATE OF COLLECTIONS. ALL OF 1927-28*			
		Pine Grove	Alfalfa Field	Arboretum	Episcopal Church
Achlya flagellata	68		1-26. (4) 2- 9. (1) 2-28. (23) 4- 5. (4) 3-12. (2) 4-19. (28)	2-21. (5)	5-17. (1)
Achlya imperfecta	13	1-10. (1)	3-19. (9)	2-21. (3)	
Achlya racemosa	4	11-18. (1) 2- 9. (1) 4-12. (1)		2-21. (1)	
Achlya orion	1	1-26. (1)			
Brevilegnia diclina	9		1-26. (4) 2-28. (1) 3- 5. (1) 4-19. (1)		5-17. (2)
Brevilegnia linearis	16	12- 6. (1) 1-26. (1)	1-26. (1) 2- 9. (2) 2-28. (7) 4- 5. (1) 4-19. (3)		
Brevilegnia unisperma	2		2-28. (2)		
Aphanomyces parasiticus	1		2-28. (1)		
Isoachlya monilifera	1	11-18. (1)			
Leptolegnia caudata	1	1-10. (1)			
Geolegnia inflata	7	1-26. (2)			5-17. (5)
Geolegnia septisporangia	6	11-18. (1) 1-26. (1)	1-26. (2) 2- 9. (1)		5-17. (1)
Allomyces arbuscula	10	11-18. (1) 12- 6. (1) 1-26. (1)	2- 9. (3) 2-28. (2) 4-19. (1)		5-17. (1)
Pythium proliferum	20	11-18. (4) 12- 6. (3) 4-12. (1)	2-28. (2) 4- 5. (7)	2-21. (3)	
Pythium monospermum	1			2-21. (1)	
Pythium deBaryanum	2		2-28. (2)		
Pythium (new)	1		1-26.		

* The figures connected by hyphen, as 1-26, 2-9, mean Jan. 26, Feb. 9, etc. The figures in parentheses give the number of times found in that locality on that date.

The results were as follows:

In series D Mucors appeared in three cultures; nothing in the others. In series E *Geolegnia inflata* appeared three times, *Brevilegnia diclina* twice, Mucors twice and four different kinds of Fungi Imperfecti once each. In series F *Geolegnia inflata* appeared twice, *Achlya flagellata* once, *Pythium* species (?) twice, Mucors twice and two Imperfects once each. In series G *Allomyces arbuscula*, once, Mucors four times, *Septoria* once.

In all the collections A-G above, the remainder of the sample after the cc. was removed was retained and cultured as a whole. It is interesting to note that in the collection A a species of *Achlya* occurred in this left-over material, whereas none appeared in the 10 dilution cultures.

In addition to the collections above mentioned, a number of others were made at random in the same pine grove where Series 6 was taken. Including the species isolated from these collections and the ones already mentioned, we have prepared the table (shown on page 138) showing the species found and other data.

In this Journal (**42**: 221. 1927) Coker gave a list of water molds that had at that time been found in the soil. It will be noted that our collections add three other species to this list, *Aphanomyces parasiticus*, *Isoachlya monilifera*, and *Leptolegnia caudata*. In addition to these, a new species of *Pythium* was found (see last item in the table above), which is to be published in the next issue of this Journal.

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